ST

Translation

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 12539	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/JP00/04472	International filing date (*day/month/year*) 05 July 2000 (05.07.00)	Priority date (*day/month/year*) 27 August 1999 (27.08.99)
International Patent Classification (IPC) or national classification and IPC H04N 1/40		
Applicant DIGITAL PUBLISHING JAPAN CO. LTD.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of ______ sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report
   II ☐ Priority
   III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   IV ☐ Lack of unity of invention
   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   VI ☐ Certain documents cited
   VII ☐ Certain defects in the international application
   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
18 January 2001 (18.01.01)	03 August 2001 (03.08.2001)
Name and mailing address of the IPEA/JP	Authorized officer
Facsimile No.	Telephone No.

Form PCT/IPEA/409 (cover sheet) (July 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/JP00/04472

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages ____________, as originally filed
pages ____________, filed with the demand
pages ____________, filed with the letter of ____________

☐ the claims:
pages ____________, as originally filed
pages ____________, as amended (together with any statement under Article 19
pages ____________, filed with the demand
pages ____________, filed with the letter of ____________

☐ the drawings:
pages ____________, as originally filed
pages ____________, filed with the demand
pages ____________, filed with the letter of ____________

☐ the sequence listing part of the description:
pages ____________, as originally filed
pages ____________, filed with the demand
pages ____________, filed with the letter of ____________

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ____________ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/ or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:
☐ the description, pages ____________
☐ the claims, Nos. ____________
☐ the drawings, sheets/fig ____________

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rule 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-7	YES
	Claims		NO
Inventive step (IS)	Claims	1-7	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-7	YES
	Claims		NO

2. Citations and explanations

[JP, 10-32719, A (BENESSE CORPORATION), 3 February 1998 (03.02.98), claims 4 and 8, Fig. 3] describes an image compressing method that converts the lateral position and luminance of each pixel into a two-dimensional vector, and converts the vertical position and luminance of each line in the vertical direction into a two-dimensional vector.

[JP, 9-298747, A (D&I SYSTEM K.K.), 18 November 1997 (18.11.97), Figs. 3 and 5] describes an image compressing method that converts the lateral position and luminance of each pixel into a two-dimensional vector, and converts the vertical position and luminance of each line in the vertical direction into a two-dimensional vector.

[JP, 4-579, A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 6 January 1992 (06.01.92), Fig. 6] describes a general technique in which deviation related to a reference vector for the maximum deviation point is repeatedly executed until it loses significance.

The aforesaid document 3 does not describe the point about "quantizing according to the magnitude of the change of the luminance, using as reference the line segment connecting the start point and end point of each column and each line," and no documents that could be combined therewith were discovered.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing: 08 March 2001 (08.03.01)	
International application No.: PCT/JP00/04472	Applicant's or agent's file reference: 12539
International filing date: 05 July 2000 (05.07.00)	Priority date: 27 August 1999 (27.08.99)
Applicant: SHINDO, Jiro	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International preliminary Examining Authority on:

18 January 2001 (18.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was [ ] was not made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer: J. Zahra Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

UMEDA, Akihiko
Umeda & Company
No.3 Seiko Building 7F
6-10, Akasaka 3-chome
Minato-ku
Tokyo 107-0052
JAPON

Date of mailing (day/month/year)
11 March 2002 (11.03.02)

Applicant's or agent's file reference
12539

IMPORTANT NOTIFICATION

International application No.
PCT/JP00/04472

International filing date (day/month/year)
05 July 2000 (05.07.00)

1. The following indications appeared on record concerning:

[X] the applicant [X] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
SHINDO, Jiro Digital Publishing Japan Co. Ltd. 196-1, Kamigamo-Motoyama Kita-ku, Kyoto-shi Kyoto 603-8047 Japan	JP	JP
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
SHINDO, Jiro Celartem Technology Inc. 196-1, Kamigamo-Motoyama Kita-ku Kyoto-shi Kyoto 603-8047 Japan	JP	JP
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Akiko KOYAMA Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

UMEDA, Akihiko
Umeda & Company
No.3 Seiko Building 7F
6-10, Akasaka 3-chome
Minato-ku
Tokyo 107-0052
JAPON

Date of mailing (day/month/year) 11 March 2002 (11.03.02)	
Applicant's or agent's file reference 12539	**IMPORTANT NOTIFICATION**
International application No. PCT/JP00/04472	**International filing date** (day/month/year) 05 July 2000 (05.07.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
DIGITAL PUBLISHING JAPAN CO. LTD. 196-1, Kamigamo-Motoyama Kita-ku, Kyoto-shi Kyoto 603-8047 Japan	JP	JP
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
CELARTEM TECHNOLOGY INC. 196-1, Kamigamo-Motoyama Kita-ku, Kyoto-shi Kyoto 603-8047 Japan	JP	JP
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Akiko KOYAMA Telephone No.: (41-22) 338.83.38

0 For use by accepting agency

0-1 International Application No.

0-2 International Filing Date

0-3 (acceptance stamp)

0-4 Format–PCT/R0/101

This international application form in accordance with Patent Cooperation Treaty was

0-4-1 Prepared according to the right: PCT-EASY Version 2.90 (updated 05.10.2000)

0-5 Instance

Applicant requests that this international application be processed in accordance with Patent Cooperation Treaty.

0-6 Accepting agency designated by applicant: Patent Office of Japan (RO/JP)

0-7 Document symbol of applicant or agent: 12539

I Title of the invention: Image data distribution method and system, image data and storage medium

II Applicant

II-1 Party entered in this column is: Applicant only

II-2 Applicant applicable to the countries designated on the right: All designated states except US

II-4ja Name: K.K. Digital Publishing Japan

II-4en Digital Publishing Japan Co., Ltd.

II-5ja Address: 196-1 Kamigamohonzan, Kita-ku, Kyoto-shi, Kyoto 603-8047, Japan

II-5en 196-1 Kamigamohonzan, Kita-ku, Kyoto-shi, Kyoto 603-8047, Japan

II-6 Nationality (Name of country): Japan JP

II-7 Address (Name of country): Japan JP

II-8 Telephone No.: 075-712-5161

II-9 Facsimile No.: 075-712-5161

III-1 Other applicant(s) or inventor(s)

III-1-1 Parties entered in this column are: Applicant and inventor

III-1-2 Applicant applicable to the country designated on the right: US only

III-1-4ja Name (Last, First): Shindo, Jiro

III-1-4en Shindo, Jiro

III-1-5ja Address: c/o K.K. Digital Publishing Japan

196-1 Kamigamohonzan, Kita-ku, Kyoto-shi, Kyoto 603-8047, Japan

III-1-5en c/o K.K. Digital Publishing Japan

196-1 Kamigamohonzan, Kita-ku, Kyoto-shi, Kyoto 603-8047, Japan

III-1-6 Nationality (Name of country): Japan JP

III-1-7 Address (Name of country): Japan JP

IV-1 Agent or assigned representative, Address to which report is made

The party below acts in the capacity indicated on in behalf of the applicant in the international organization: Agent

IV-1-1ja Name (Last, First): Umeda, Akihiko

IV-1-1en Umeda, Akihiko

IV-1-2ja Address: c/o Umeda & Company No. 3 Seiko Building 7F

3-6-10 Akasaka, Minato-ku, Tokyo 107-0052, Japan

IV-1-2en c/o Umeda & Company No. 3 Seiko Building 7F

3-6-10 Akasaka, Minato-ku, Tokyo 107-0052, Japan

IV-1-3 Telephone No.: 03-3560-8117

IV-1-4 Facsimile No.: 03-3560-8210

V Designation of countries

V-1 World patent (Enter other types of protection or handling in parentheses when so requested.):

EA: AM AZ BY KG KZ MD RU TJ TM and other signatory states of the Patent Cooperation Treaty with Eurasian Patent Treaty

EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and other signatory states of the Patent Cooperation Treaty with European Patent Agreement

V-2 National patent (Enter other types of protection or handling in parentheses when so requested.): CN JP KR US

V-5 Declaration of confirmation on designation

Applicant designates all other Patent Cooperation Treaty contracting states according to the provisions of regulation 4.9 (b) in addition to the designation above. However, designation of the states indicated in column V-6 is excluded. Applicant declares that these additional designations are required to be confirmed, that those designations not confirmed within 15 months of the priority date are considered to have been withdrawn by the applicant once said period has expired.

V-6 States excluded from confirmation on designation: None

VI-1 Priority claimed based on previous national applications

VI-1-1 Previous Filing Date: July 20, 1999 (07.20. 1999)

VI-1-2 Previous Application No.: Patent Application No. Hei 11[1999]-283296

VI-1-3 Name of country: Japan JP

VI-2 Request for delivery of priority certificate

Transcripts of acceptance of those applications cited above that are indicated on the right should be sent by the accepting agency to the International Secretariat: VI-1

VII-1 International search agency (ISA) designated: Patent Office of Japan (ISA/JP)

VIII	Reference	Number of pages	Electronic data attached
VIII-1	Application	3	
VIII-2	Specifications	15	
VIII-3	Claims	2	
VIII-4	Abstract	1	abst...txt
VIII-5	Figures	16	
VIII-7	Total	37	

	Document attached	Attached	Electronic data attached
VIII-8	Statement of fees	✓	
VIII-9	Separate power of attorney with signature and seal	✓	

VIII-16 PCT-EASY disk Flexible disk

VIII-18 No. of figures to be presented with abstract

VIII-19 Language used for international application: Japanese

IX-1 Signature and seal of submitter

IX-1-1 Name (Last, First): Umeda, Akihiko [seal]

Column for use by Accepting Agency

10-1 Actual reception date of document submitted as international application

10-2 Figure:

10-2-1 & 10-2-2 Lacking figure(s) received

10-3 Actual reception date (corrected date) of document or figure which completes the document submitted as international application and submitted subsequently within said period

10-4 Reception date within the required period for completion in accordance with Item 11 (2) of Patent Cooperation Treaty

10-5 International search agency designated by applicant: ISA/JP

10-6 Manuscript for investigation not sent to international search agency because search fee is not paid

Column for use by International Secretariat

11-1 Reception date of original record manuscript

[recurring header:] [pages 1-2 of 2]

International Application Form in accordance with Patent Cooperation Treaty

Original copy (for application) – Time and date printed July 5, 2000 (07.05. 2000) Monday 16 h. 24 min. 15 sec.

(This form does not constitute any part of international application and is not international application)

0	Column for use by accepting agency			
0-1	International Filing No.			
0-2	Stamp of date by accepting agency			
0-4	Form-PCT/R0/101 (attachment)			
	This PCT fee statement			
0-4-1	was prepared according to the right: PCT-EASY Version 2.90 (updated 05.10.2000)			
0-9	Document symbol of applicant or agent: 12539			
2	Applicant: K.K. Digital Publishing Japan			
12	Calculation of prescribed fees		Amount/factor	Subtotal (JPY)
12-1	Handling charge	T	⇨	18,000
12-2	Investigation fee	S	⇨	72,000
12-3	International fees			
	Basic fee (Up to first 30 pages) b1		46,000	
12-4	Number of pages in excess of 30: 7			
12-5	Fee per page (X): 1100			
12-6	Total fees b2: 7700			
12-7	b1 + b2 =	B	53,700	
12-8	Designated fees: 6			
	Number of countries designated in international application: 6			
12-9	Number of designated fees to be paid (maximum of 8): 6			
12-10	Fee per 1 designation (X): 9,900			
12-11	Total designated fees D: 59,400			
12-12	Reduction in fees due to PCT-EASY R: –14,200			
12-13	Total international fees (B+D–R) I:		⇨	98,900
12-14	Priority certificate request fee: 1			
	Number of request for priority certificate: 1			
12-15	Fee per 1 priority certificate (X): 1,400			

12-16 Total of priority certificate request fees P: ⇨ 1,400

12-17 Total fees to be paid (T+S+I+P): 190,300

12-19 Method of payment: Transfer to bank account

Result of EASY check and reference made by applicant

13-2-2 Result of EASY check: Green?

Designated states: More designations can be made. (Following states remain undesignated:

AP:(GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW); OA:(BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG); AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, LI, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW)

Please confirm them.

13-2-10 Result of EASY check: Green?

Column for use by accepting agency/International Secretariat: PCT-EASY used for preparing this application runs on Windows using non-English or a non-western-European language. Please compare application with electronic data carefully with respect to characters other than ASCII characters.

Power of attorney

June 30, 2000

I would like to appoint Mr. Akihiko Umeda, attorney, as our agent and grant him the following rights.

1. All matters concerning

International patent applications in accordance with Patent Cooperation Treaty

2. Matters concerning the withdrawal of the aforementioned applications and specification of designated countries

3. All matters concerning requests for international preliminary examinations of the aforementioned applications and matters concerning the withdrawal of requests and the designation of selected countries

Address 196-1 Kamigamohonzan, Kita-ku, Kyoto-shi, Kyoto

Name: K.K. Digital Publishing Japan

Representative: Jiro Shindo

[Pages 1–18]
Specifications

IMAGE COMPRESSION METHOD

Technological field

The present invention pertains to an image compression method for compressing digital image data, such as a full-color image with additive primary colors (RGB) or subtractive primary colors (CMY) or a monochrome image with 256 levels (gray scale).

Background of the technology

In general, digital image data comprising luminance information for the respective color elements, that is, respective color channels (color model), in a color model, such as the RGB system or the CMY system, is utilized for computer processing of a color image. Said digital image data is represented by 1 byte (8 bits) of information for expressing the luminance levels of the respective colors (RGB) of 1 pixel using values in 256 steps (256 gradations), that is, 0 through 255, so that 1 pixel has 3 bytes of information. Thus, a superfine color image contains an enormous amount of data, which means that not only hardware resources, such as a large-capacity memory, a hard disk drive, a high-speed CPU, and communications technology capable of realizing high-speed data transfer, but also a data compression technique are required in order to process said image data using a computer.

Although a variety of data compression methods have been suggested, some of these use techniques that reduce the quality when a compressed image is decompressed. For example, based on the fact that image data does not necessarily use every color, there is a method in which appropriate, preset color subtraction is applied in order to reduce the file size without destroying the original image. With this kind of compression method involving color subtraction, because similar color values are integrated during the compression process, the continuity of the color scale is lost, and fine lines, in particular, tend to become blurred. In addition, there is a known compression method in which luminance information is converted into color difference information when the color information is stored. However, the amount of significant information contained in color difference information is approximately 1/4 or less that in luminance information, which means that hues tend to be reproduced incorrectly.

In addition, Japanese Kokai Patent Application No. Hei 10[1998]-32719 discloses an image compression method and a device in which color image data comprising luminance information for the 3 primary colors is converted into color model data comprising 1 luminance information and 2 color difference information which is then compressed using a method capable

of high quality reproduction in order to achieve a sufficiently high compression rate and reproduced image quality. 3D vector quantization is adopted for said compression processing technique for high-quality reproduction; wherein, a group of horizontal pixel groups having luminance levels which can be assumed to change successively within a fixed allowable error range on an XZ plane, is expressed using a single vector unit, where distribution of the luminance levels of respective pixels on the XY image plane is expressed in terms of magnitude in the direction of the Z axis, and a group of vertical pixel groups having luminance levels which can be assumed to change successively within a fixed allowable error range on the XZ plane is expressed using a single vector unit in the same manner. When the image compression method according to the aforementioned Kokai patent application is utilized, while the compression rate can be improved significantly over the prior art, because conversion into color information is applied before compression, the reproduced picture quality tends to be degraded when the image data is expanded by decompression.

Thus, the purpose of the present invention is to present an image compression method by which successive changes in hue can be reproduced accurately, fine lines can also be reproduced clearly, and a high-quality image good enough to serve as an image manuscript for printing can be reproduced while also realizing a superior compression effect with superfine digital image data.

Disclosure of the invention

With the present invention, an image compression method characterized in that respective horizontal rows of bitmap digital image data with a single or multiple color channels are 2D-vectored according to the positions of the respective pixels in the horizontal direction and their luminance levels and are quantized according to the change in the luminance levels with reference to the line elements connecting the starting points and the end points of the aforementioned respective rows, and

respective vertical rows of the aforementioned horizontally vectored and quantized image data are 2D-vectored according to the positions of the respective pixels and their luminance levels according to the degrees of change in the luminance levels with reference to the line elements connecting the starting points and the end points of the aforementioned respective rows,

in order to convert it into compressed image data in matrix form based on the significance levels of the luminance information of the respective pixels can be presented.

Because the luminance information for each pixel contained in the image data is 2D-vectored and quantized according to the change in the luminance levels in order to hierarchize and reconstruct the data based on the significance levels in the information for each pixel, luminance information for pixels with no substantial significance are absorbed into the

same vector. Therefore, the amount of original image data can be reduced without substantially losing the information contained in said data, and the most efficient data structure for compressing superfine image data, in particular, can be created.

In one application example, original bitmap digital image data are divided into image data units of a prescribed size, horizontal vectoring and quantization and subsequent vertical vectoring and quantization are applied to the respective divided image data units in order to convert them into compressed image data units in matrix form, and the respective compressed image data units are integrated at the end. Accordingly, even when the original image contains a relatively large amount of data, it can be processed efficiently in accordance with the processing capability of the computer and the required image quality.

In another application example, after the original bitmap digital image data are divided into respective color channels, and the divided image data on the respective color channels are converted into respective compressed image data in matrix form, they are integrated into a single compressed image data unit. Accordingly, because the processing unit of image data according to the RGB system or the CMY system, for example, can be reduced to 1/3 its prior size, it can be processed efficiently.

In addition, when the aforementioned original bitmap digital image data is divided into image data units of a prescribed size, after said respective image data units are further divided for the respective color channels, and the divided image data units for the respective color channels are converted into respective compressed image data units in matrix form, they are integrated into one compressed image data unit; whereby, even more efficient compression processing can be realized.

Furthermore, with the present invention, the compressed image data in matrix form generated in the aforementioned manner can be further compressed mathematically. As a result, image data can be compressed at an even higher level without any loss.

In one application example, the horizontal or vertical quantization process involves a process in which line elements connecting the starting points and the end points of respective columns or respective rows are used as reference vectors for calculating positive and/or negative maximum deviation points in said sections, and line elements connecting each two neighboring points at the starting points, the end points, and the maximum deviation points are used as new reference vectors for calculating new positive and/or negative maximum deviation points in said sections in order to calculate said maximum deviation points and is repeated until the deviations of the respective maximum points with respect to the reference vectors lose their significance as desired image data, and respective pixels are divided according to the degree of deviation at the respective maximum deviation points in order to generate multiple hierarchical data containing different numbers of bits.

For example, when the original bitmap digital image data is 8-bit data, it is preferable that the aforementioned multiple hierarchical data are constructed as first through fourth hierarchical data comprising 8 bits, 6 bits, 4 bits, and 1 bit, respectively.

Brief description of the figures

Figure 1 is a flowchart showing the outline of a preferred application example of the image compression method in accordance with the present invention.

Figure 2 is a flowchart showing the process of step 3 in Figure 1 in which image data is divided into optimum processing units.

Figure 3 is a flowchart showing the outline of the process in step 4 in Figure 1 in which image data divided into optimum processing units are vectored in order to generate image data in matrix form.

Figure 4 is a flowchart showing the process in which image data is vectored in the horizontal direction in order to generate first hierarchical data.

Figure 5 is a flowchart showing the process in which image data is vectored in the horizontal direction in order to generate second hierarchical data.

Figure 6 is a flowchart showing the process in which image data is vectored in the horizontal direction in order to generate third hierarchical data.

Figure 7 is a flowchart showing the process in which image data is vectored in the horizontal direction in order to generate fourth hierarchical data.

Figure 8 is a flowchart showing the outline of the process in which vertical vectoring is applied to the horizontally vectored image data after processing.

Figure 9 is a flowchart showing the process in which post-treatment is applied to the image data vectored in the horizontal and vertical directions in order to generate a VFZ image file of the present invention.

Figure 10 is a flowchart showing the process in which the generated VFZ image file of the present invention is reproduced.

Figure 11 is a diagram showing an example of the division of the image data.

Figure 12 is a diagram in which the image data divided in Figure 11 are further divided into RGB color channels, respectively.

Figure 13A is a diagram showing a horizontal row of image data on color channel R; and Figure 13B a linear diagram showing luminance levels relative to luminance distribution, that is, positions (lengths from the origin) of the pixels, for explaining the concept of vectoring.

Figure 14A is a diagram showing first through fourth hierarchical data generated from 1 horizontal row through vectoring; and Figure 14B is a diagram showing the condition in which shaping processing is applied to the horizontally vectored image data in all rows.

Figure 15 is a schematic diagram showing the distribution of the first through the fourth hierarchical data of the image data vectored in the horizontal and vertical directions.

Figure 16 is a diagram showing the arrangement of the image data vectored in the horizontal and vertical directions.

Preferred embodiment for the implementation of the invention

Image compression method of the present invention will be explained in detail below using a preferred application example with reference to the attached figures.

Figure 1 is a flowchart showing the outline of the process in which a compressed image file is generated from a full-color image manuscript, that is, the original image, using the method in accordance with an application example of the present invention. First, the desired image manuscript is processed electronically in order to generate image data as bitmap data with multiple color channels as in an RGB system or CMY system or monochromatic channel expressed only by means of a gray scale (step S1). Usually, this type of image data is generated at arbitrary input resolutions and luminance levels based on prescribed amounts of information, for example, 12 bits, 8 bits (1 byte), and 1 bit (binary), using a variety of known means, such as an image scanner and a digital camera. The image data is input on-line to a processing computer or a workstation via a network utilizing a storage medium, such as a CD-R, an MO disk, and a DVD, and Ethernet (step S2) in order to carry out the image compression process of the present invention.

The aforementioned processing computer applies pre-treatment to the image data input and stores it in memory (step S3). First, as shown in Figure 2, all the image data is unarchived into memory (step S21). Next, after the information contained in the header label of the image data is interpreted, and the size (number of dots) of the entire image, structure of color channels, and the amount (number of bits) of luminance information allocated per pixel are confirmed, the image data is divided into optimum processing units of a predetermined image size according to the interpretation results, and the divided respective unit image data are reconstructed in the memory (step S22). Said optimum processing unit may be preset to a fixed image size, or it may be selected depending on the processing capability and memory capacity of the processing computer and the required image reproduction condition, such as image quality.

In the present application example, as shown in Figure 11, compression processing is applied to RGB color image data at a resolution of 1024 x 1024 dots. Assuming that the optimum processing unit is 256 x 256 dots, the image data in Figure 11 is divided into fourths in the vertical and horizontal directions and reconstructed into a total of 16 unit image data. Each pixel of said RGB unit image data contains a total of 3 bytes of information (luminance value) for the R, G, B color channels, respectively. Next, as shown in Figure 12, said unit image data is divided

into unit image data corresponding to the respective color channels (R, G, B) and reconstructed in memory (step S23). Unit image data on said respective color channels are used as a minimum processing unit for data compression processing. The unit image data on a single color channel contains 1 byte of information (luminance value) per pixel. Thus, the amount of data in the minimum processing unit is reduced to 256 x 256 bytes from 1024^2 x 3^2 required for processing the entire original image data.

Next, vector-resolution processing is applied in sequence to the unit image data on each single color channel within each optimum processing unit in order to generate image data converted into matrix form (step S4). As shown in Figure 3, first, horizontal vectoring is applied row by row to the minimum processing unit image data on the respective color channels in sequence in order to generate first through fourth hierarchical data which are distinguished from one another by the amount (number of bits) of luminance information for the respective pixels (step S31).

Horizontal vectoring will be explained in detail using Figures 4 through 7. As shown in Figure 13A, within the minimum processing unit image data, each horizontal row is configured with 256 contiguous pixels, and each pixel has a luminance value expressed using 1 byte of information. In Figure 13B, positions of respective pixels within 1 horizontal row are expressed by means of length (0 through 255) along the horizontal axis, and luminance values of the respective pixels are expressed by means of 256 stages (0 through 255) along the vertical axis in order to show the luminance distribution of the pixels in 1 horizontal row. In the present invention, said distribution is replaced by a 2D vector having a length (x) and a luminance value (y) in order to express luminance information for the respective pixels, so that information on the luminance distribution and continuous changes in luminance can be kept when the image data is vectored.

More specifically, the first pixel in the first row is taken as starting point P1 (x1 = 0, y1), the last pixel is taken as the end point P2 (x2 = 255, y2), and the line element connecting them is taken as master vector P1P2 = [x2 – x1, y2 – y1] (step S41). Next, luminance deviations of other pixels in the section between the starting point and the end point are calculated relative to the master vector in order to determine points D1 (x11, y11) and D2 (x12, y12) of positive and negative maximum deviation (step S42). Then, xy 2D subvectors P1D1 = [x11 – x1, y11 – y1], D1D2 = [x12 –x11, y12 – y11], and D2P2 = [x2 – x12, y2 – y12] are generated, respectively, in the same manner between each two neighboring points, that is, P1 and D1, D1 and D2, and D2 and P2 (step S43). In addition, although there may be a case in which only one positive or negative deviation is present with reference to the master vector, that is, there is only one point which represents the maximum deviation, subvectors are generated in the same manner between each two neighboring points from respective line elements connecting them.

At this time, whether the absolute values of the deviations at the maximum deviation points (D1 and D2) are 64 or less [sic; less than 64], that is, whether the amount of information is 6 bits or less, is determined (step S44). If they are not 64 or less, that is, if they are greater than [64], the determination is made that said point (D1 or D2) contains information that should be expressed in 8 bits regarding the change in luminance relative to the starting point and the end point. On the other hand, if they are 64 or less, because the determination is made that said point (D1 or D2) contains information that should be expressed in 6 bits or less regarding the amount of change in luminance relative to the starting point and the end point, first hierarchy data generation process at the section between the starting point and the end point is ended, and advancement is then made to second hierarchy data generation process.

If the absolute values of the maximum deviations are 64 or more, the aforementioned subvectors generated between each two neighboring points containing said points D1 and/or D2 are stored as first hierarchy data in memory (step S45). As shown in Figure 14A, these subvectors are arranged in sequence using 2 values (x and y) each containing 8 bits of information as 1 data.

Furthermore, luminance deviations are calculated with reference to the respective subvectors for the respective sections between each two neighboring points, that is, P1 and D1, D1 and D2, and D2 and P2, in order to determine points D11, D12, D21, D22, D31, and D32 which assume positive and negative maximum deviations. Next, steps S43 through S45 carried out for the first maximum deviation points (D1 and D2) are repeated for all of these newly determined maximum deviation points until the absolute values of those maximum deviations become 64 or less.

In other words, xy 2D subvectors, such as P1D11, D11D12, and D12D1, are generated in the same manner between each two neighboring points at the respective 2 points which constitute the new maximum deviation points (D11, D12, D21, D22, D31, and D32) and their reference subvectors (step S43). Then, whether the absolute values of the maximum deviations are 64 or less is determined (step S44), wherein, if they are 64 or less, the first hierarchy data generation process is ended for said sections, and advancement is then made to the second hierarchy data generation process. If they are greater than 64, the newly generated subvectors are added in the same manner to the first hierarchy data using 2 values (x and y). In this manner, the first hierarchy data shown in Figure 14A is generated in the memory.

During the second hierarchy data generation process, as shown in Figure 5, whether or not the absolute values of the maximum deviations relative to the reference vectors are 16 or less is determined with respect to the points where the maximum deviations have been judged to be 64 or less in step S44 of the first hierarchy data generation process (step S51). If they are not 16 or less, that is, if they are greater than said value, the determination is made that said points

contain information regarding the amount of change in luminance relative to the reference subvectors that should be expressed in 6 bits. On the other hand, if they are 16 or less, because the determination is made that said points contain information regarding the change in luminance relative to the reference subvectors that should be expressed in 4 bits or less, the second hierarchy data generation process is ended, and advancement is then made to the third hierarchy data generation process.

If the absolute values of the maximum deviations are greater than 16, the subvectors generated between each two neighboring points containing said points in step S43 of the first hierarchy data generation process are stored in memory as second hierarchical data (step S52). As shown in Figure 14A, these subvectors are arranged successively using 2 values (x and y) each containing 6 bits of information as 1 data. Furthermore, luminance deviations are calculated with reference to the respective subvectors for the respective sections between each two neighboring points in order to determine points which assume positive and negative maximum deviations.

Next, at all of the newly determined maximum deviation points and the respective 2 points constituting their reference subvectors, xy 2D subvectors are generated in the same manner between each two neighboring points (step S53). Then, whether the absolute values of the maximum deviations at the new deviation points are 16 or less is determined (step S51); wherein, if they are 16 or greater, the newly generated subvectors are added to the second hierarchy data using 2 values (x and y).

Steps S51 through S53 are repeated until the absolute values of the maximum deviations of all the newly determined deviation points are less than 16. Subvectors which are determined to be greater than 16 are added sequentially as second hierarchy data, and the second hierarchy data shown in Figure 14A is stored in memory.

As shown in Figure 6, the third hierarchical data generation process is carried out in the same manner as the generation process of the second hierarchy data. That is, whether or not the absolute values of the maximum deviations relative to their reference vectors are 4 or less is determined with respect to the points where the maximum deviations have been determined to be less than 16 in step S51 of the second hierarchy data generation process (step S61). If they are not 4 or less, that is, they are greater than said value, the determination is made that they contain information regarding the change in luminance relative to the reference subvectors that should be expressed in 4 bits. On the other hand, if they are 4 or less, because the determination is made that they contain information regarding the change in luminance relative to the reference subvectors that should be expressed in 2 bits or less, the third hierarchy data generation process is ended, and advancement is then made to the fourth hierarchy data generation process.

If the absolute values of the maximum deviations are greater than 4, the subvectors generated between each two neighboring points containing their maximum deviation points in step S53 of the second hierarchy data generation process are stored in memory as third hierarchy data (step S62). These subvectors are arranged successively using 2 values (x and y) each containing 4 bits of information as 1 data, as shown in Figure 14A. Furthermore, luminance deviations are calculated with reference to respective subvectors at respective sections connecting each two neighboring points in order to determine positive and negative maximum deviation points.

Next, at all of the newly determined maximum deviation points and the respective 2 points constituting their reference subvectors, xy 2D subvectors are generated in the same manner between each two neighboring points (step S63). Then, whether or not the absolute values of the maximum deviations at the new deviation points are 4 or less is determined (step S61), wherein, if they are 4 or more, the newly generated subvectors are added to the third hierarchy data using 2 values (x and y).

Similarly, steps S61 through S63 are repeated until the absolute values of the maximum deviations of all the newly determined deviation points are less than 4. Subvectors which are determined to be greater than 4 are added sequentially as third hierarchy data, and the third hierarchy data shown in Figure 14A is stored in memory.

During the fourth hierarchy data generation process, as shown in Figure 7, whether the absolute values of the maximum deviations relative to their reference vectors are 1 or 0 is determined with respect to the points where the maximum deviations have been determined to be less than 4 in step S61 of the third hierarchy data generation process (step S71). If they are 1 or 0, because the determination is made that said points contain information regarding the change in luminance relative to the reference subvectors that should be expressed with 1 bit, subvectors generated between each two neighboring points containing said points are also stored as fourth hierarchy data using 2 values (x and y) as shown in Figure 14A (step S72).

If the absolute values of the maximum deviations are not 1 or 0, the determination is made that said points contain information greater than 1 bit regarding the change in luminance relative to the reference subvectors. In this case, luminance deviations are further calculated with reference to the subvectors generated between each two neighboring points containing the maximum deviation points in step S63 of the third hierarchy data generation process in order to determine points of positive and negative maximum deviation (step S73). Then, xy 2D subvectors are generated between each two neighboring points at the respective points constituting the newly determined maximum deviation points and their reference subvectors (step S74), and whether or not the absolute values of said maximum deviations are 1 or 0 is determined (step S71).

The determination is made that all of the maximum deviation points generated in said manner contain information regarding the change in luminance relative to their subvectors that should be expressed with 1 bit, and the steps S71, 73, and 74 are repeated until fourth hierarchy data is stored in memory. Accordingly, the data at the remaining points after the generation of the third hierarchy data are all converted into vectors each having 2 values (x and y) and generated into fourth hierarchy data.

In this manner, vector-resolution processing is applied to changes in luminance of the respective pixels in the respective rows of the minimum processing unit image data in order to generate the first through fourth hierarchy data with different numbers of bits according to size and to arrange them in memory in the order of first to 256th row. At this time, information on the starting points (P1) and the end points (P2) in the original image data, that is, length in the horizontal direction and luminance values, is placed in the leading parts of the respective rows. In addition, data indicating the boundaries between the respective hierarchy data are inserted between them.

In the aforementioned process, in which post-treatment is applied to the minimum processing unit image data in the horizontal direction, and the first through fourth hierarchy data are generated, because the respective rows of the image data divided into the minimum processing units are further processed independently, the data size subjected to 1 set of processing is small. In addition, because the original data is no longer needed once said data is reconstructed after it is unarchived into certain areas in the memory and processed, those areas can be freed for subsequent processing. Thus, in the present invention, memory of the processing computer can be utilized more effectively than heretofore. Moreover, because the respective rows in the horizontal direction can be processed in parallel simultaneously or with some delay depending on the processing capability, the processing speed can be significantly improved. In addition, image data for large format can be processed even with a processing computer with a relatively low capacity.

Needless to say, the data lengths of the first through fourth hierarchy data are different for the respective rows. Thus, in the present application example, one with the longest data length is selected from the entire rows for the respective hierarchy data, and it is used as reference data length, wherein, if the data length is longer than said reference data length, value "0" is entered into respective insufficient data length areas shaded in Figure 14B. Accordingly, the minimum processing unit image data is formed in such a way that the respective hierarchy data have the same data length from the first to the 256th row, that is, the respective rows in the vertical direction are configured with the same 256 continuous data, before it is reconfigured in memory (step S32).

Next, the horizontally vectored image data in Figure 14B are vectored in sequence for the respective rows in the vertical direction (step S33). Respective rows are vectored in the same way as for the aforementioned horizontal vectoring according to the process shown in Figure 8 in order to generate the first through fourth hierarchy data for the respective rows. First, a master vector $Q1Q2 = [z2 - z1, y2 - y1]$ is generated with respect to the leading first row with reference to its starting point Q1 ($z1 = 0$, y1) and end point Q2 ($z2 = 255$, y2) (step S81).

Next, in the section connecting the aforementioned starting point and the end point, luminance deviations of other pixels are calculated with reference to the master vector in order to determine points V1 (z11, y11) and V2 (z12, y12) of positive and/or negative maximum deviations (step S82). Then, zy 2D subvectors $Q1V1 = [z11 - z1, y11 - y1]$, $V1V2 = [z12 - z11, y12 - y11]$, and $V2Q2 = [z2 - z12, y2 - y12]$ are generated between each two neighboring points, that is, Q1 and V1, V1 and V2, and V2 and Q2, in the same manner (step S83). Here, y1, y2, y11, and y12 used for the respective points Q1, Q2, V1, and V2 are different from y1, y2, y11, and y12 for the respective points P1, P2, D1, and D2 used for the horizontal vectoring.

As in the process described above in connection with Figure 4 during the horizontal vectoring, whether or not the absolute values of the deviations at the maximum deviation points V1 and V2 are 64 or less is decided; wherein, if they are greater than 64, subvectors, each containing 8 bits of information and expressed using 2 values (z and y), are stored in memory as first hierarchy data. Then, new positive and negative maximum deviation points are further determined with reference to said subvectors, and are added to memory as long as the absolute values of said deviations exceed 64 in order to generate first hierarchical data.

When the absolute values of the maximum deviations all become 64 or less at the newly determined maximum deviation points, advancement is made to the second hierarchy data generation process in the same manner, and vectoring is applied according to the same process described above in connection with Figure 5 in order to generate second hierarchy data configured only with data having 6 bits of information to be stored in memory. Next, after vectoring is applied in the same manner as that described above in connection with Figure 6 in order to generate third hierarchy data configured only with data having 4 bits of information to be stored in memory, fourth hierarchy data configured only with data having 1 bit of information is generated and stored in memory through the same vector processing as that described above in connection with Figure 7 (step S84).

During said vertical vectoring, too, as described above in connection with the horizontal vectoring, because the respective steps for generating the first through fourth hierarchy data are carried out independently for small size data, the original memory areas for the reconstructed data can be freed in sequence for subsequent processing, so that effective utilization of the memory can be achieved, and the processing speed can be improved significantly through

parallel processing of the respective rows, either concurrently or with delays. In addition, even relatively large amounts of image data can be processed using a processing computer of relatively low capacity.

As shown in Figure 14B, because the starting point, end point, and the divisions of the first through fourth hierarchy data are already obtained for the image data subjected to the vertical vector-resolution processing, while the first through fourth hierarchy data are all generated from the starting point, the end point, and the first hierarchy data; only the second through the fourth hierarchy data are generated from the second hierarchy data; only the third and the fourth hierarchy data are generated from the third hierarchy data; and only the fourth hierarchy data is generated from the fourth hierarchy data. In fact, the present inventor applied the image compression processing of the present application example to several full-color test images and confirmed that the first through fourth hierarchy data resulted in fixed proportions represented approximately by area a, area b + c, area d + e + f, and area g + h + i + j shown in Figure 15.

Next, shaping is applied in order to arrange these data groups (a through j) in the order of first through fourth hierarchy data shown in Figure 16, that is, according to bit size, for reconfiguration in the memory (step S85).Thus, compressed image data with the desired matrix form can be obtained from the minimum processing unit, that is, unit image data with a single channel (step S4).

In the present invention, luminance data for the respective pixels are vectored in this manner, and the data are hierarchized and reconfigured according to their significance levels; wherein, luminance information for pixels with no essential significance can be absorbed into 1 vector. Therefore, when hierarchized simply in this manner, the amount of data can be reduced without essentially losing the information contained in the original file. Particularly, the most efficient data structure can be created during the compression of superfine image data with a large amount of information. In addition, because the hierarchies are achieved by dividing the data with reference to a fixed number of bits during the processing in which the image data applied with 2D vectoring in the horizontal and the vertical directions are hierarchized and reconfigured, the processing may be referred to as quantization.

Said image data is compressed using a technique of the prior art (step S5). Compression processing is applied to the first through fourth hierarchy data, respectively, using a mathematical compression method for which known run-length compression processing and Huffman compression processing are combined, for example. Accordingly, the compressed data in accordance with the present invention is generated per single-channel unit image data. In the present invention, because the image data is hierarchized in this manner, improved mathematical compression relative to that of conventional compression techniques can be realized.

Furthermore, because mathematical compression is applied in addition to the hierarchization of the image data, despite the fact that the image data can be compressed at a high compression rate, no essential image data is lost.

Vector-resolution processing is also applied to the other two color channels which constitute the same optimum processing unit image data in order to convert them into image data having the aforementioned matrix form, and compression processing is also applied in order to generate compressed image data in accordance with the present invention.

Next, in step S6, the compressed image data generated individually for the 3 color channels in said manner are integrated in order to generate optimum processing unit RGB compressed image data and stores it in memory (step S91). Once compressed image data for the 16 units of image data are all generated, they are integrated in order to generate a VFZ image file of the present invention representing the compressed version of the entire original image data (step S92). In this case, a header label indicating the file size and data structure is inserted to the leading part of the VFZ image file.

To reproduce the original color image, the VFZ image file is output on-line from the processing computer or using a storage medium, such as a CD-R, to a computer for reproduction or a workstation via an ordinary network (step S7). Reproduction conditions, such as output resolution and image size, are input to the computer for reproduction. The VFZ image file is decompressed, and image data with the aforementioned matrix structure is generated based on the aforementioned reproduction conditions. The image data is output directly onto the screen of a prescribed display device from the reproducing computer, or it is stored into a storage device, such as a server, prior to its on-line transfer.

Because the image data output has the aforementioned matrix structure described in connection with Figure 16, the entire image is displayed on the screen at the point when the first hierarchical data output in advance is input, finer images are displayed as the second and subsequent hierarchical data are input, and the original superfine color image is reproduced at the end as the entire data are input.

Although a case involving the compression of RGB system image data was explained in the aforementioned application example, the present invention can also be applied to a color image utilizing CMY system or other formats as well as image data having a monochromatic channel, such as gray scale, in the same manner. In addition, as it is clear to an expert in the field, the present invention may also be implemented with additions of a variety of changes and modifications to the aforementioned application example without exceeding its technological scope.

Claims

1. An image compression method characterized in that respective horizontal rows of bitmap digital image data with a single or multiple color channels are 2D-vectored according to the positions of the respective pixels in the horizontal direction and their luminance levels and are quantized according to the change in the luminance levels with reference to the line elements connecting the starting points and the end points of the aforementioned respective rows, and

respective vertical rows of the aforementioned horizontally vectored and quantized image data are 2D-vectored according to the positions of the respective pixels and their luminance levels according to the degrees of change in the luminance levels with reference to the line elements connecting the starting points and the end points of the aforementioned respective rows,

in order to convert it into compressed image data in matrix form based on the significance levels of the luminance information of the respective pixels.

2. The image compression method of Claim 1, characterized in that the aforementioned bitmap digital image data is divided into unit image data of a prescribed size,

horizontal vectoring and quantization and subsequent vertical vectoring and quantization are applied to the divided unit image data in order to convert them into unit compressed image data in matrix form, and

the aforementioned unit compressed image data are integrated.

3. The image compression method of Claim 1, characterized in that after the aforementioned bitmap digital image data is divided into respective color channels, and the divided image data for the respective color channels are converted into respective compressed image data in matrix form, they are integrated into 1 compressed image data.

4. The image compression method of Claim 2, characterized in that after the aforementioned divided unit image data is further divided for the respective color channels, and the divided unit image data for the respective color channels are converted into respective unit compressed image data in matrix form, they are integrated into 1 unit compressed image data.

5. The image compression method of one of Claims 1-4, characterized in that it includes a process in which mathematical compression is further applied to the aforementioned compressed image data in matrix form.

6. The image compression method of one of Claims 1-4, characterized in that the aforementioned horizontal or vertical quantization process contains a process in which line elements connecting the starting points and the end points of the aforementioned respective columns or the respective rows are used as reference vectors for calculating positive and/or negative maximum deviation points in said sections, and line elements connecting each two neighboring points at the aforementioned starting points, the end points, and the aforementioned maximum deviation points are used as new reference vectors for calculating new positive and/or

negative maximum deviation points in said sections in order to calculate said maximum deviation points and is repeated until the deviations of the aforementioned respective maximum points with respect to the reference vectors lose their significance as desired image data, and respective pixels are divided according to the degree of deviation at the aforementioned respective maximum deviation points in order to generate multiple hierarchical data containing different numbers of bits.

7. The image compression method of Claim 6, characterized in that when the aforementioned bitmap digital image data is 8-bit data, the aforementioned multiple hierarchical data are constructed as first through fourth hierarchical data comprising 8 bits, 6 bits, 4 bits, and 1 bit, respectively.

Abstract

Bitmap digital image data having one or more color channels is divided into image sizes corresponding to an optimum processing unit set according to computer's processing capability and requested image quality, and each unit image data is further divided according to the respective color channels in order to generate multiple minimum processing units of image data. After respective horizontal rows of the minimum processing unit of image data are 2D-vectored based on the horizontal positions x and luminance levels y of the respective pixels therein, quantized according to changes in luminance levels using line elements connecting the starting points and end points of the respective rows as reference vectors, and applied with shaping processing, the respective vertical rows are 2D-vectored based on the horizontal positions x and luminance levels y in the same manner and quantized according to the changes in luminance levels using line elements connecting the starting point and the end point of the respective rows as reference vectors in order to convert the image data into compressed image data with a matrix structure based on the significance of the luminance information contained in the respective pixels. After said minimum units of compressed image data are further compressed mathematically, the color channels are integrated in order to generate optimum processing units of compressed image data; and they are further integrated in order to generate compressed image data for the entire original image.

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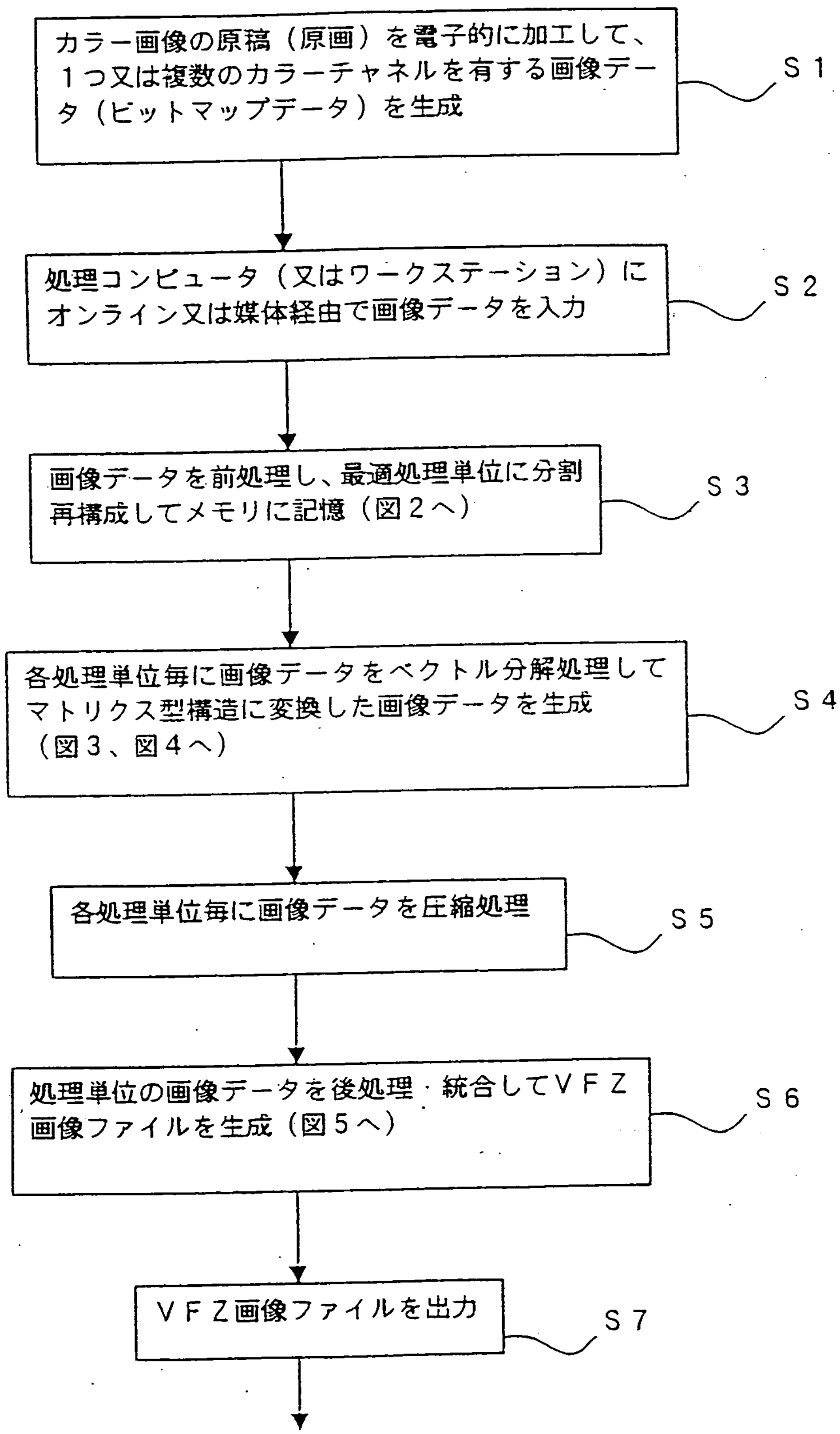
Ⓐ図１


カラー画像の原稿（原画）を電子的に加工して、１つ又は複数のカラーチャネルを有する画像データ（ビットマップデータ）を生成
Ｓ１
処理コンピュータ（又はワークステーション）にオンライン又は媒体経由で画像データを入力
Ｓ２
画像データを前処理し、最適処理単位に分割再構成してメモリに記憶（図２へ）
Ｓ３
各処理単位毎に画像データをベクトル分解処理してマトリクス型構造に変換した画像データを生成（図３、図４へ）
Ｓ４
各処理単位毎に画像データを圧縮処理
Ｓ５
処理単位の画像データを後処理・統合してＶＦＺ画像ファイルを生成（図５へ）
Ｓ６
ＶＦＺ画像ファイルを出力
Ｓ７

[Key to previous page:]

A Figure 1

S1 Original color image manuscript (original image) is processed electronically in order to generate image data (bitmap data) having one or more color channels

S2 Image data is input into processing computer (or workstation) on-line or via a medium

S3 Pre-treatment is applied to the image data in order to divide it into optimum processing units stored in memory after they are reconfigured (to Figure 2)

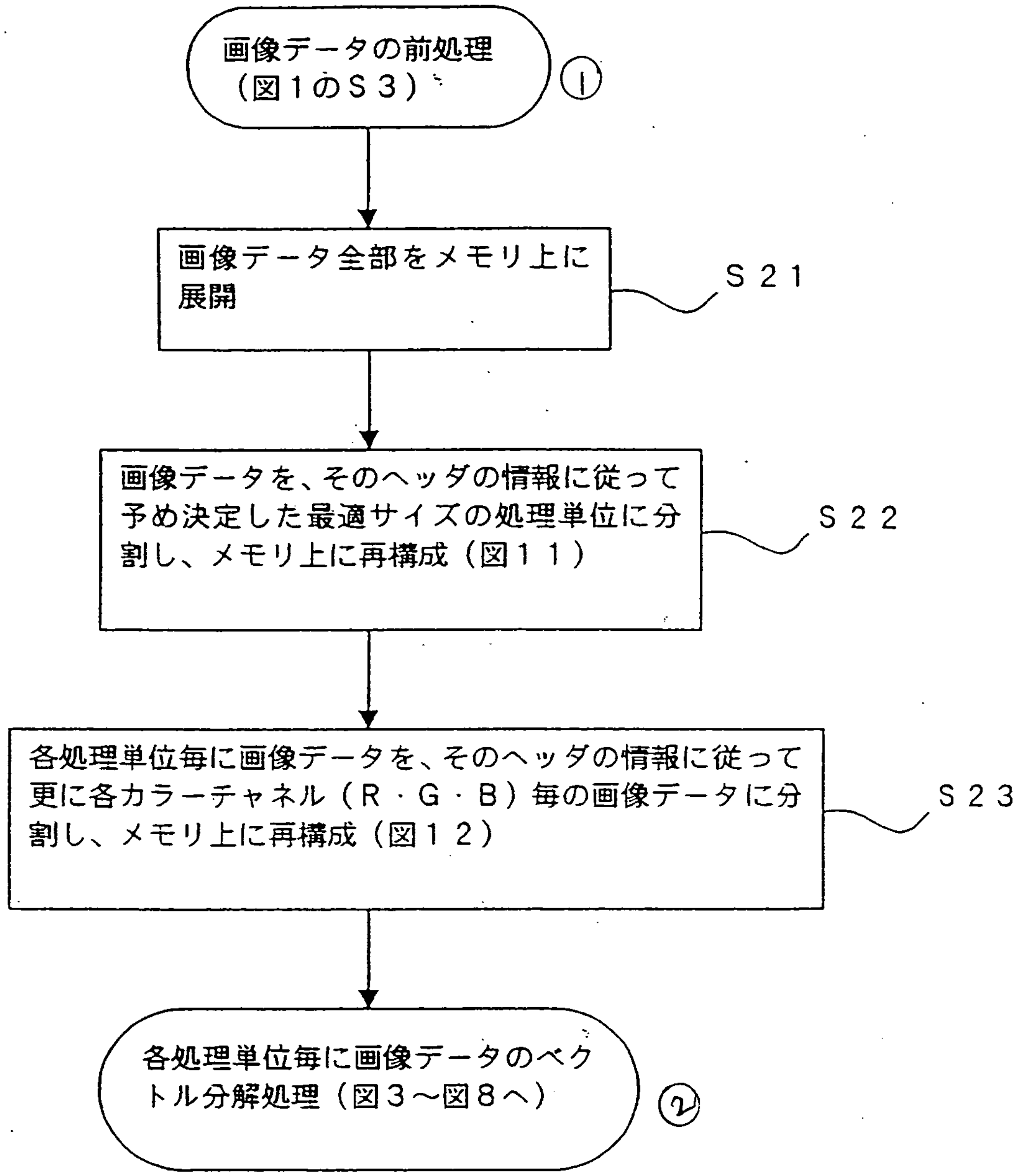
S4 Vector-resolution processing is applied to each processing unit of image data in order to convert it into image data in matrix form (to Figures 3 and 4)

S5 Compression processing is applied to each processing unit of image data

S6 Processing units of image data are applied with post-treatment and integrated in order to generate an VFZ image file (to Figure 5)

S7 VFZ image file is output

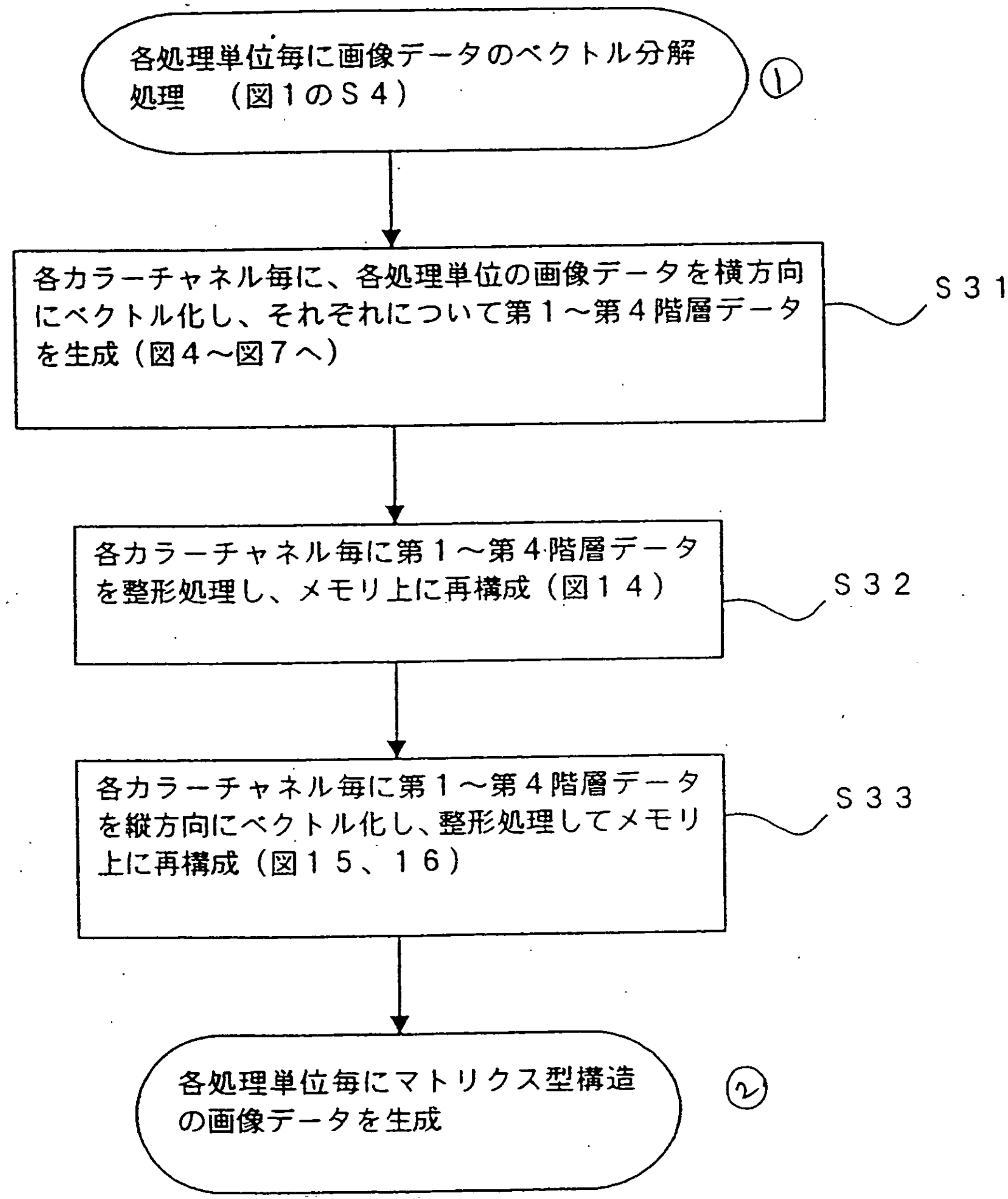
図2Ⓐ


画像データの前処理
(図1のS3)
①
画像データ全部をメモリ上に
展開
S21
画像データを、そのヘッダの情報に従って
予め決定した最適サイズの処理単位に分
割し、メモリ上に再構成(図11)
S22
各処理単位毎に画像データを、そのヘッダの情報に従って
更に各カラーチャネル(R・G・B)毎の画像データに分
割し、メモリ上に再構成(図12)
S23
各処理単位毎に画像データのベク
トル分解処理(図3～図8へ)
②

[Key to previous page:]

A Figure 2
1 Pre-treatment of image data (S3 in Figure 1)
2 Vector-resolution processing is applied to each processing unit of image data (to Figures 3-8)
S21 Entire image data is unarchived into memory
S22 Image data is divided into processing units of a prescribed optimum size according to its header information and reconfigured in the memory (Figure 11).
S23 Each processing unit of image data is further divided into image data on the respective color channels (R, G, B) according to its header information and reconfigured in memory (Figure 12)

図３Ⓐ


各処理単位毎に画像データのベクトル分解処理　（図１のＳ４）
①
各カラーチャネル毎に、各処理単位の画像データを横方向にベクトル化し、それぞれについて第１～第４階層データを生成（図４～図７へ）
Ｓ３１
各カラーチャネル毎に第１～第４階層データを整形処理し、メモリ上に再構成（図１４）
Ｓ３２
各カラーチャネル毎に第１～第４階層データを縦方向にベクトル化し、整形処理してメモリ上に再構成（図１５、１６）
Ｓ３３
各処理単位毎にマトリクス型構造の画像データを生成
②

[Key to previous page:]

A Figure 3

1 Vector-resolution processing is applied to each processing unit of image data (S4 in Figure 1)

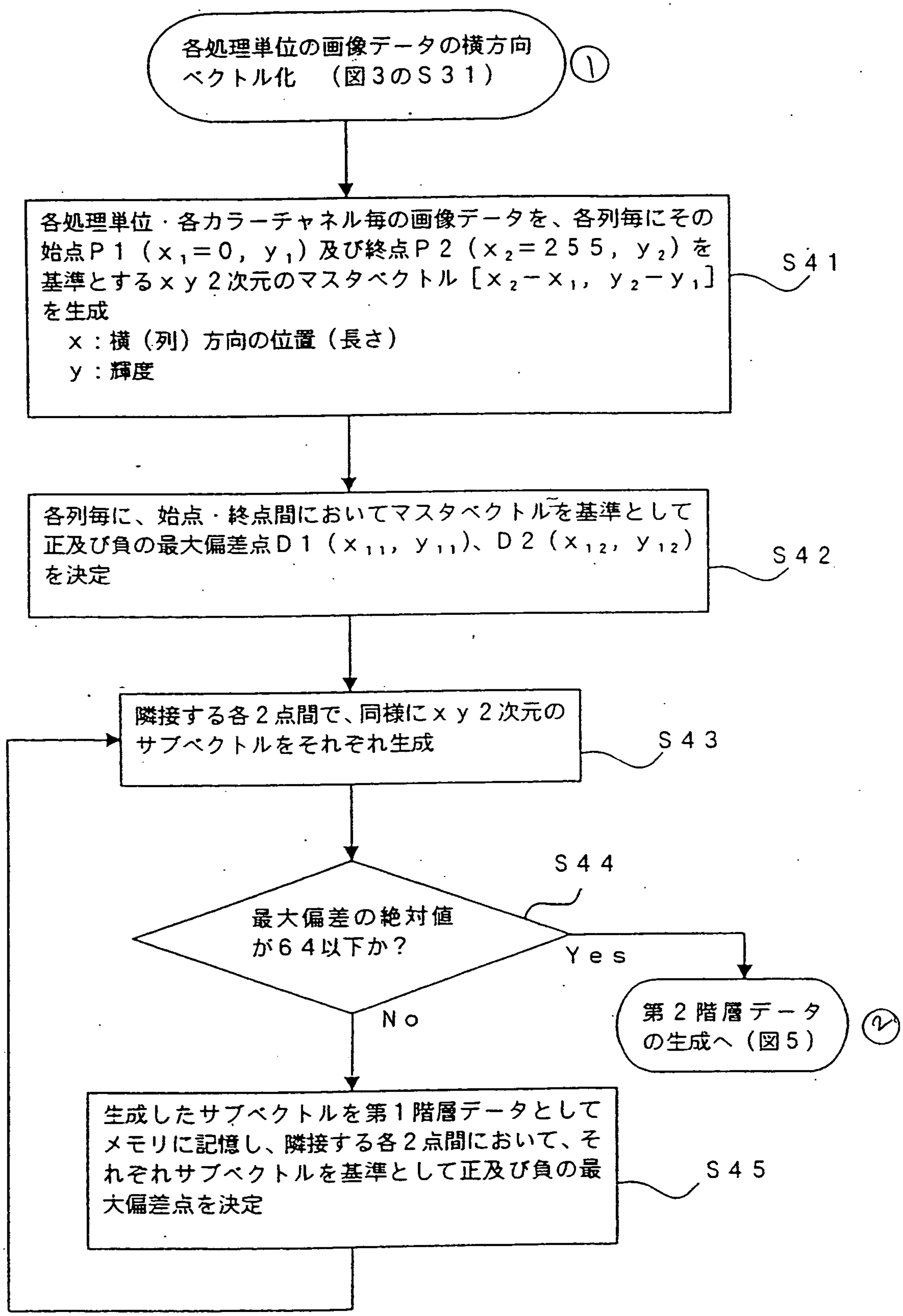
2 Image data with the matrix structure are generated per processing unit

S31 Horizontal vectoring is applied to each processing unit of image data for the respective color channels in order to generate respective first through fourth hierarchical data (to Figures 4-7)

S32 First through fourth hierarchical data are shaped per color channel and reconfigured in memory (Figure 14)

S33 First through fourth hierarchical data are vertically vectored per color channel, shaped, and reconfigured in memory (Figures 15 and 16)

図４ A

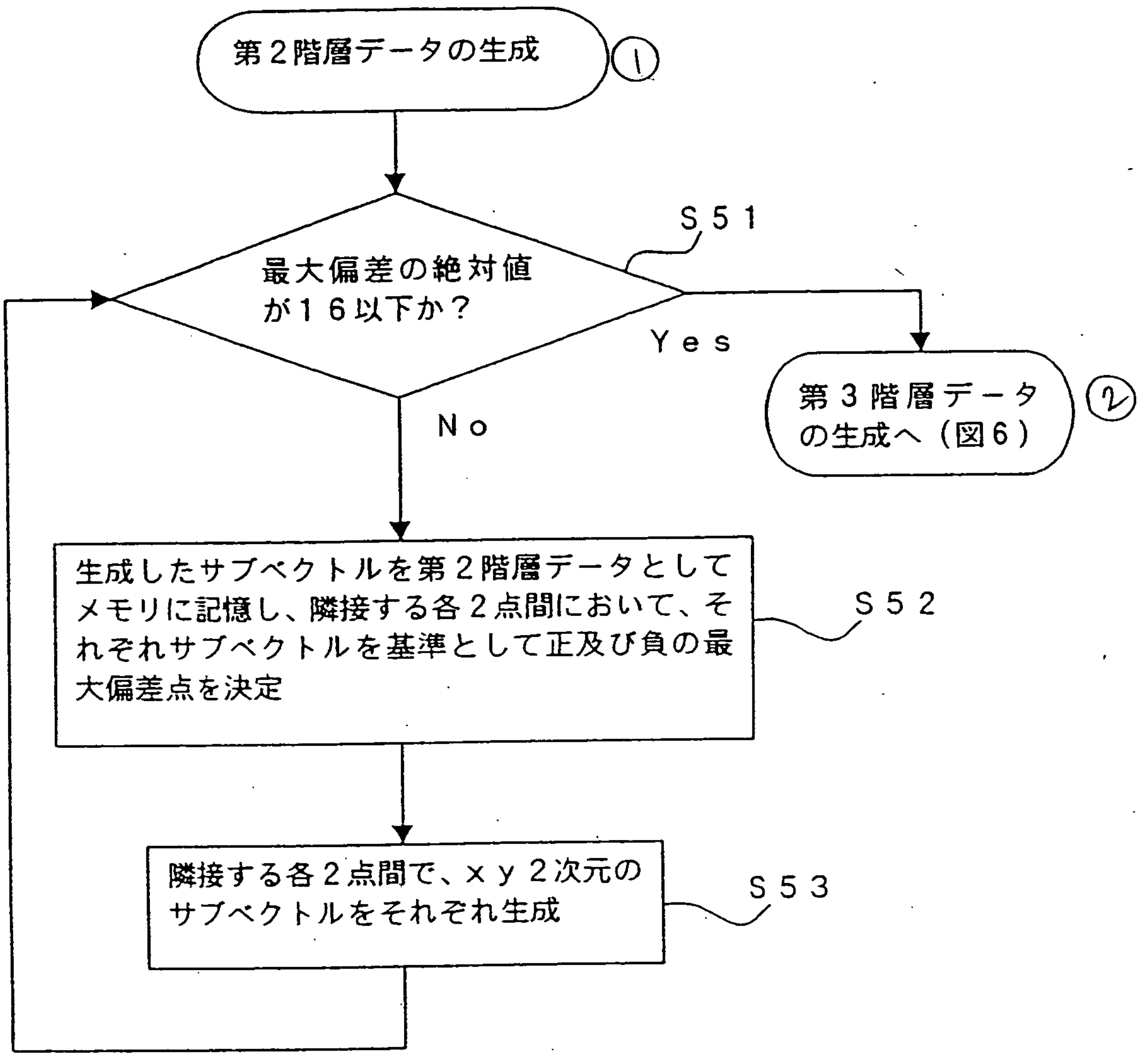


各処理単位の画像データの横方向ベクトル化　（図３のＳ３１）
1
各処理単位・各カラーチャネル毎の画像データを、各列毎にその始点Ｐ１（x_1＝０，y_1）及び終点Ｐ２（x_2＝２５５，y_2）を基準とするｘｙ２次元のマスタベクトル［x_2－x_1，y_2－y_1］を生成
ｘ：横（列）方向の位置（長さ）
ｙ：輝度
Ｓ４１
各列毎に、始点・終点間においてマスタベクトルを基準として正及び負の最大偏差点Ｄ１（x_{11}，y_{11}）、Ｄ２（x_{12}，y_{12}）を決定
Ｓ４２
隣接する各２点間で、同様にｘｙ２次元のサブベクトルをそれぞれ生成
Ｓ４３
Ｓ４４
最大偏差の絶対値が６４以下か？
Ｙｅｓ
Ｎｏ
第２階層データの生成へ（図５）
2
生成したサブベクトルを第１階層データとしてメモリに記憶し、隣接する各２点間において、それぞれサブベクトルを基準として正及び負の最大偏差点を決定
Ｓ４５

[Key to previous page:]

A	Figure 4
1	Horizontal vectoring of each processing unit of image data (S31 in Figure 3)
2	To the generation of second hierarchical data (Figure 5)
S41	xy 2D master vector $[x_2 - x_1, y_2 - y_1]$ is generated for each row in reference to the starting point P1 ($x_1 = 0$, y_1) and end point P2 ($x_2 = 255$, y_2) of each processing unit and each color channel of the image data x: Position (length) in the horizontal (row) direction y: Luminance
S42	Positive and negative maximum deviation points D1 (x_{11}, y_{11}) and D2 (x_{12}, y_{12}) between the starting point and end point are determined for each row with reference to the master vector
S43	xy 2D subvectors are generated between each two neighboring points in the same manner
S44	Absolute values of the maximum deviations are 64 or less?
S45	Subvectors generated are stored in memory as first hierarchical data, and positive and negative maximum deviation points are determined between each two neighboring points with reference to respective subvectors

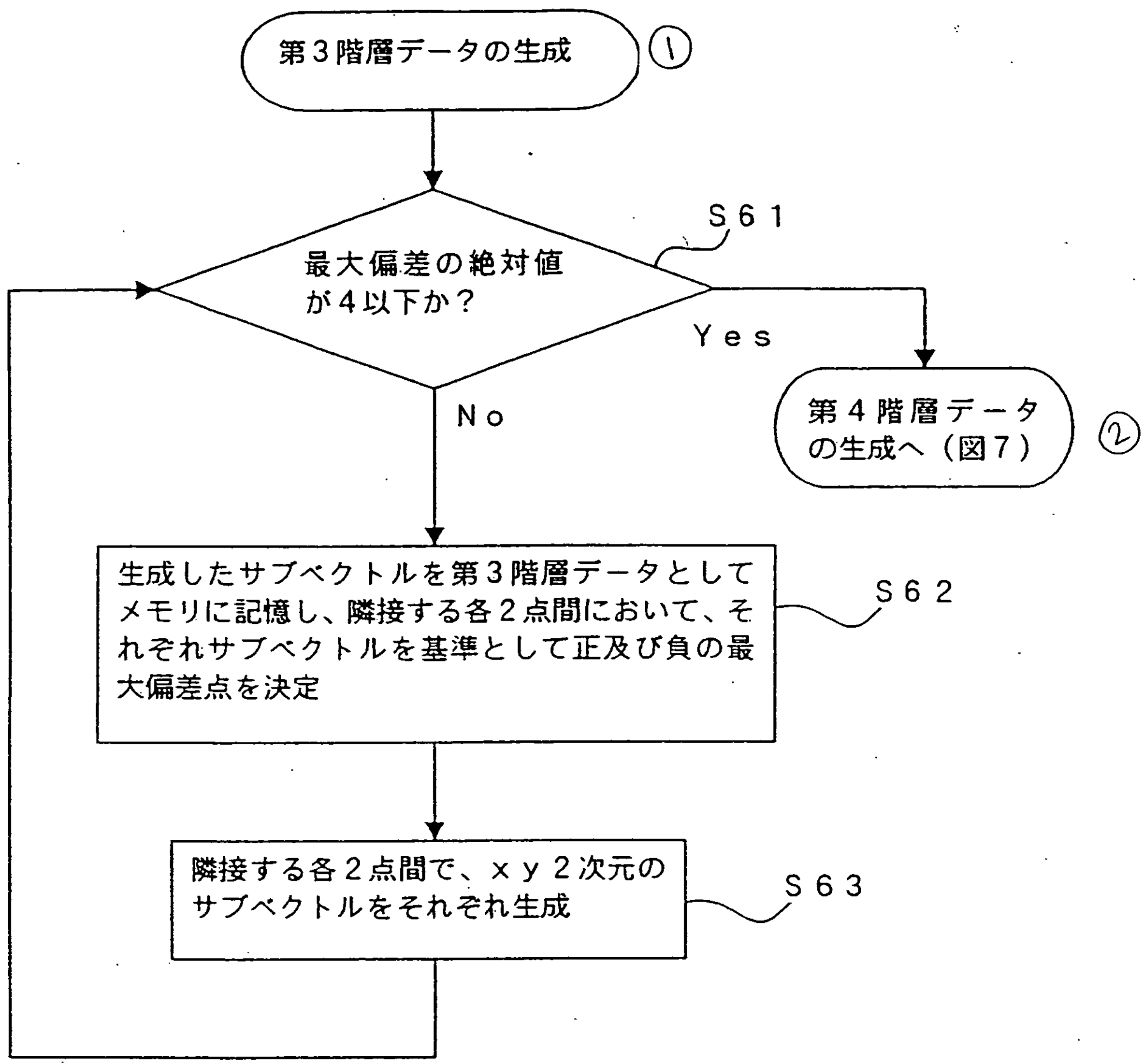
図５Ⓐ


第２階層データの生成
①
最大偏差の絶対値
が１６以下か？
S５１
Yes
第３階層データ
の生成へ（図６）
②
No
生成したサブベクトルを第２階層データとして
メモリに記憶し、隣接する各２点間において、そ
れぞれサブベクトルを基準として正及び負の最
大偏差点を決定
S５２
隣接する各２点間で、ｘｙ２次元の
サブベクトルをそれぞれ生成
S５３

[Key to previous page:]

A	Figure 5
1	Generation of second hierarchical data
2	To the generation of third hierarchical data (Figure 6)
S51	Absolute values of the maximum deviations are 16 or less?
S52	Subvectors generated are stored in memory as second hierarchical data, and positive and negative maximum deviation points are determined between each two neighboring points in reference to respective subvectors
S53	xy 2D subvectors are generated between each two neighboring points

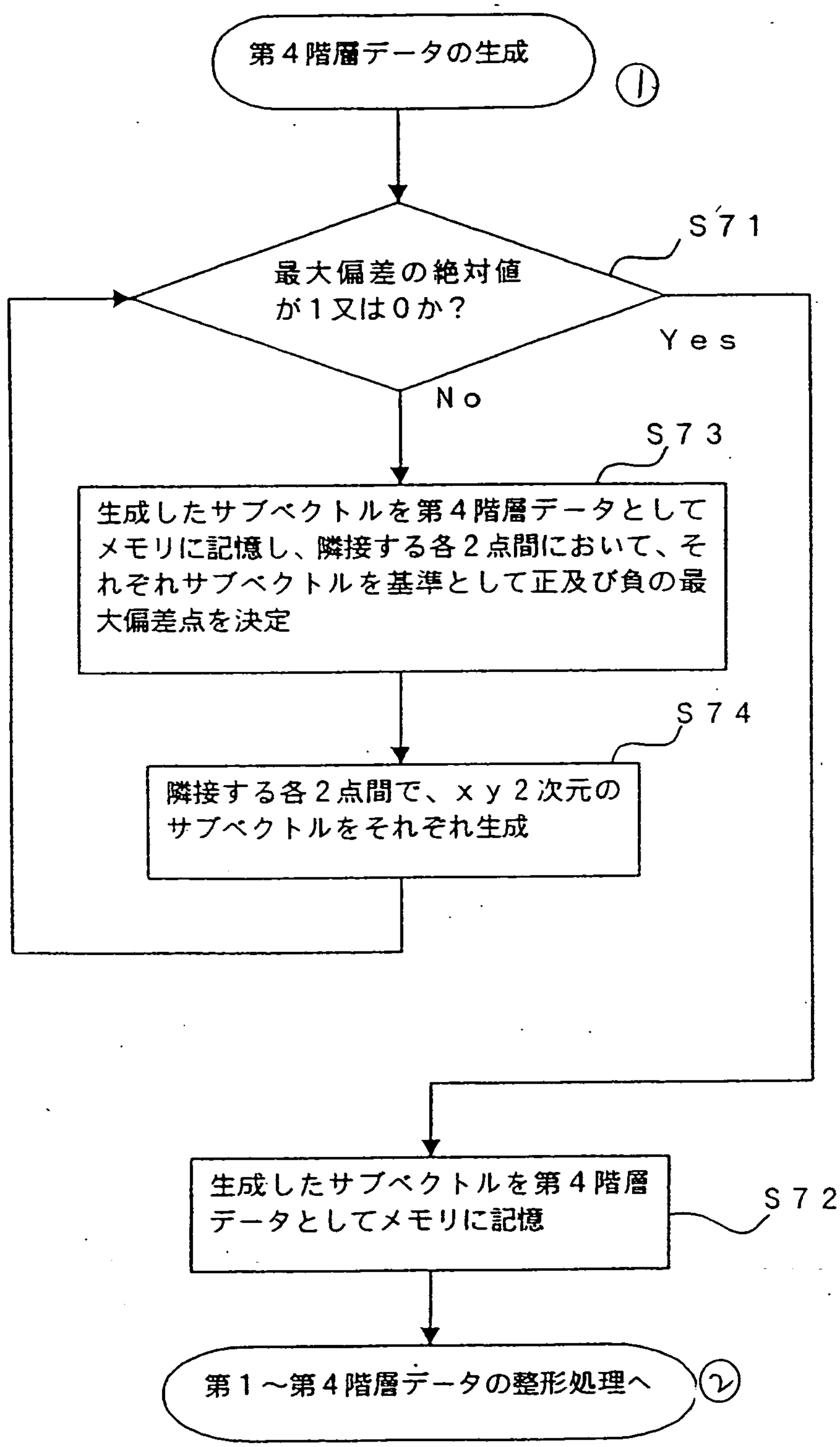
図６Ⓐ


第３階層データの生成
①
Ｓ６１
最大偏差の絶対値
が４以下か？
Ｙｅｓ
第４階層データ
の生成へ（図７）
②
Ｎｏ
生成したサブベクトルを第３階層データとして
メモリに記憶し、隣接する各２点間において、そ
れぞれサブベクトルを基準として正及び負の最
大偏差点を決定
Ｓ６２
隣接する各２点間で、ｘｙ２次元の
サブベクトルをそれぞれ生成
Ｓ６３

[Key to previous page:]

A Figure 6
1 Generation of third hierarchical data
2 To the generation of fourth hierarchical data (Figure 7)
S61 Absolute values of the maximum deviations are 4 or less?
S62 Subvectors generated are stored in memory as third hierarchical data, and positive and negative maximum deviation points are determined between each two neighboring points with reference to respective subvectors
S63 xy 2D subvectors are generated between each two neighboring points

図７ A

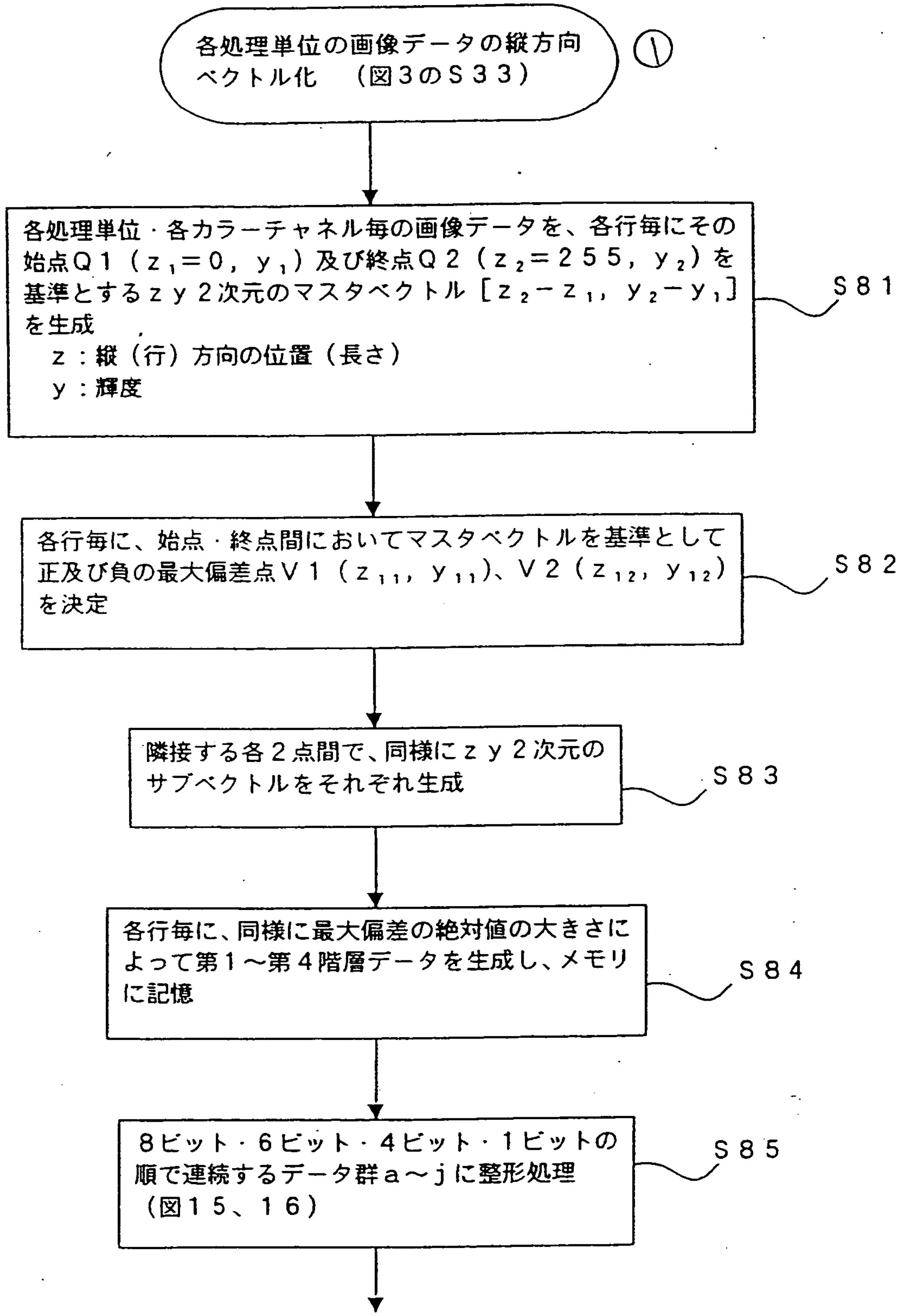


第４階層データの生成
1
最大偏差の絶対値が１又は０か？
Ｓ７１
Ｙｅｓ
Ｎｏ
Ｓ７３
生成したサブベクトルを第４階層データとしてメモリに記憶し、隣接する各２点間において、それぞれサブベクトルを基準として正及び負の最大偏差点を決定
Ｓ７４
隣接する各２点間で、ｘｙ２次元のサブベクトルをそれぞれ生成
生成したサブベクトルを第４階層データとしてメモリに記憶
Ｓ７２
第１～第４階層データの整形処理へ
2

[Key to previous page:]

A Figure 7
1 Generation of fourth hierarchical data
2 To shaping processing of the first through the fourth hierarchical data
S71 Absolute values of the maximum deviations are 1 or 0?
S72 Subvectors generated are stored in memory as fourth hierarchical data
S73 Subvectors generated are stored in memory as fourth hierarchical data, and positive and negative maximum deviation points are determined between each two neighboring points with reference to respective subvectors
S74 xy 2D subvectors are generated between each two neighboring points

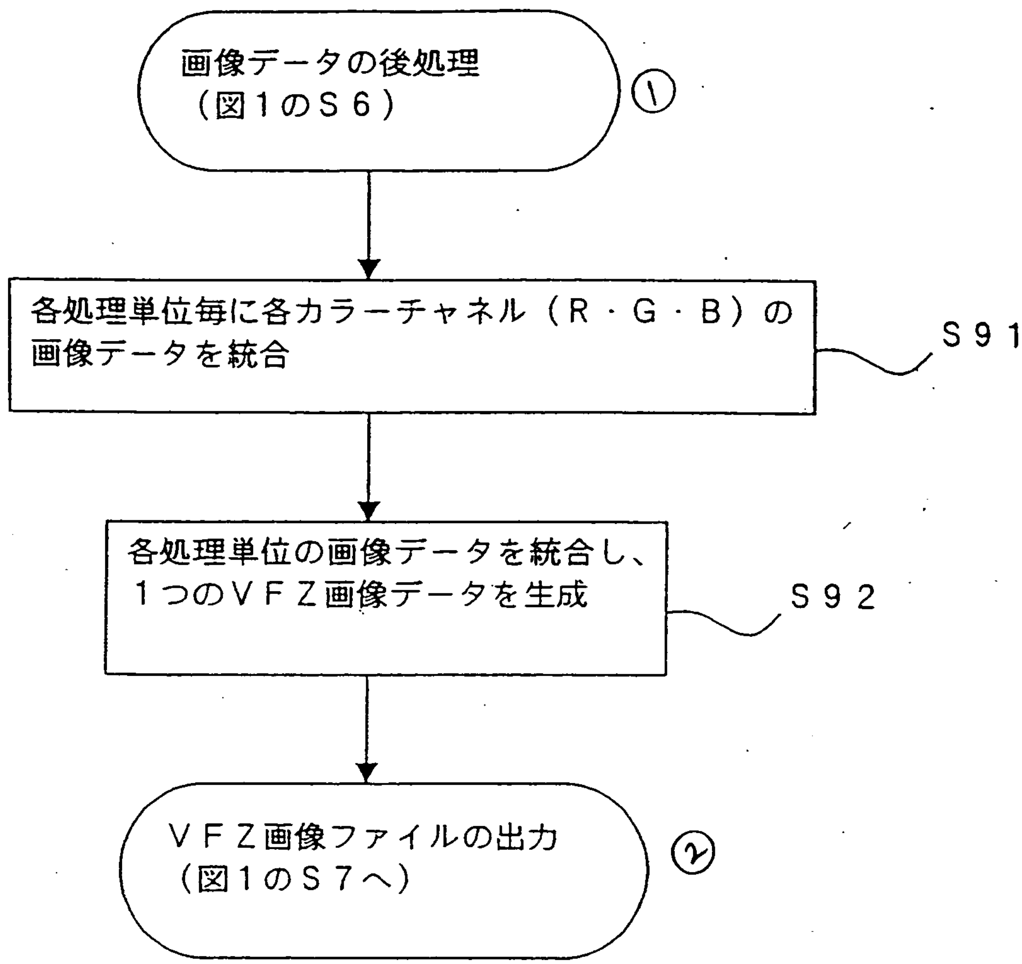
図８ Ⓐ


各処理単位の画像データの縦方向ベクトル化　（図３のＳ３３）
①
各処理単位・各カラーチャネル毎の画像データを、各行毎にその始点Ｑ１（z_1＝０，y_1）及び終点Ｑ２（z_2＝２５５，y_2）を基準とするｚｙ２次元のマスタベクトル［z_2-z_1，y_2-y_1］を生成
ｚ：縦（行）方向の位置（長さ）
ｙ：輝度
Ｓ８１
各行毎に、始点・終点間においてマスタベクトルを基準として正及び負の最大偏差点Ｖ１（z_{11}，y_{11}）、Ｖ２（z_{12}，y_{12}）を決定
Ｓ８２
隣接する各２点間で、同様にｚｙ２次元のサブベクトルをそれぞれ生成
Ｓ８３
各行毎に、同様に最大偏差の絶対値の大きさによって第１～第４階層データを生成し、メモリに記憶
Ｓ８４
８ビット・６ビット・４ビット・１ビットの順で連続するデータ群ａ～ｊに整形処理（図１５、１６）
Ｓ８５

[Key to previous page:]

A Figure 8
1 Vertical vectoring of each processing unit of image data (S33 in Figure 3)
S81 xy 2D master vector $[z_2 - z_1, y_2 - y_1]$ is generated for each row with reference to the starting point Q1 ($z_1 = 0$, y_1) and end point Q2 ($z_2 = 255$, y_2) of each processing unit and each color channel of the image data
z: Position (length) in the horizontal (row) direction
y: Luminance
S82 Positive and negative maximum deviation points V1 (z_{11}, y_{11}) and V2 (z_{12}, y_{12}) between the starting point and end point are determined for each row with reference to the master vector
S83 zy 2D subvectors are generated between each two neighboring points in the same manner
S84 First through fourth hierarchical data are generated for respective rows according to the absolute values of the maximum deviations in the same manner and stored in memory
S85 Shaping processing is applied to create data groups a through j arranged in sequence in the order of 8 bits, 6 bits, 4 bits, and 1 bit (Figures 15 and 16)

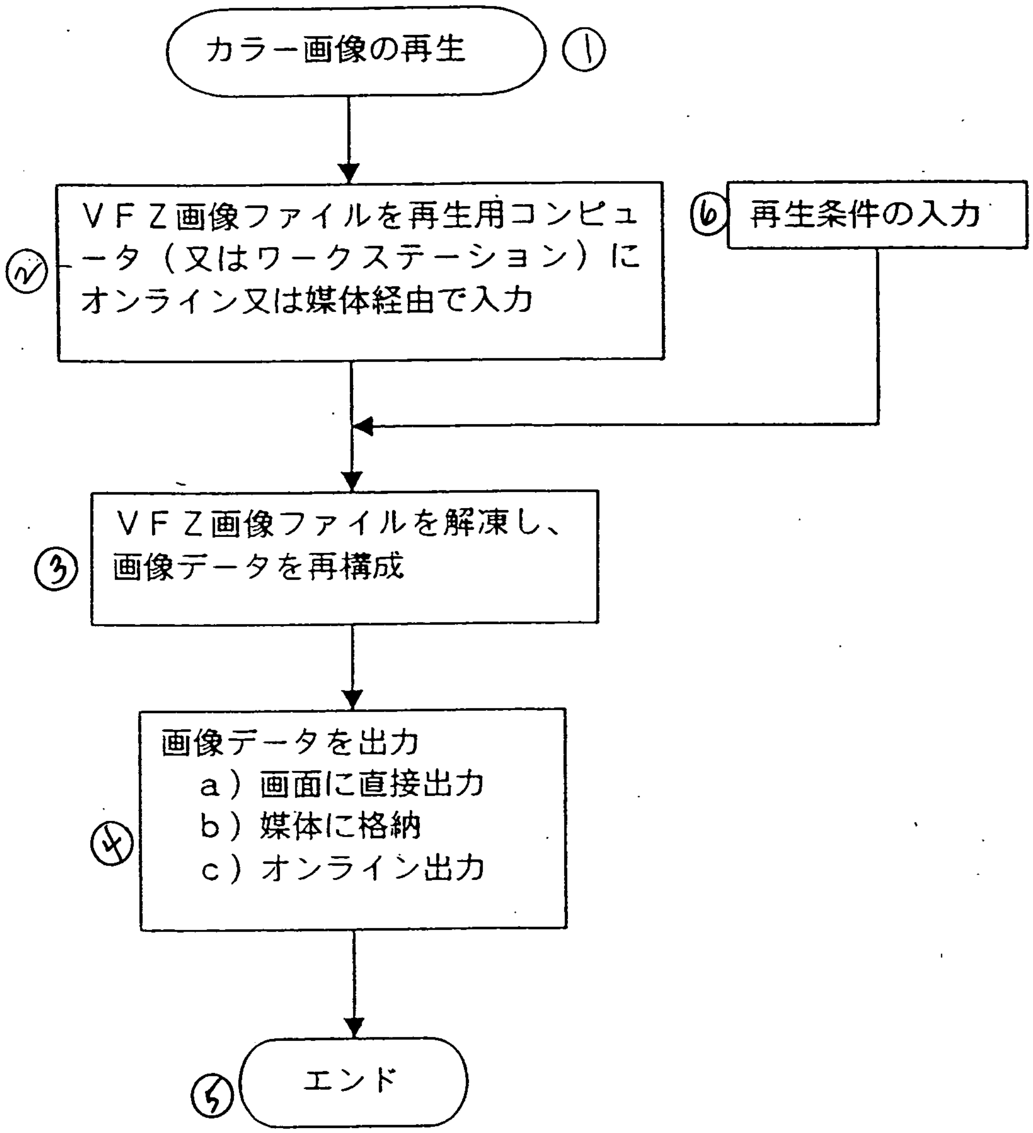
図９ A


画像データの後処理
（図１のＳ６）
1
各処理単位毎に各カラーチャネル（Ｒ・Ｇ・Ｂ）の画像データを統合
Ｓ９１
各処理単位の画像データを統合し、１つのＶＦＺ画像データを生成
Ｓ９２
ＶＦＺ画像ファイルの出力
（図１のＳ７へ）
2

[Key to previous page:]

A	Figure 9
1	Post-treatment of image data (S6 in Figure 1)
2	VFZ image file is output (To S7 in Figure 1)
S91	Image data for the respective color channels (R, G, B) are integrated per processing unit
S92	Respective processing units of image data are integrated in order to generate 1 VFZ image data

図１０ Ⓐ



カラー画像の再生
①
ＶＦＺ画像ファイルを再生用コンピュータ（又はワークステーション）にオンライン又は媒体経由で入力
②
⑥
再生条件の入力
ＶＦＺ画像ファイルを解凍し、画像データを再構成
③
画像データを出力
ａ）画面に直接出力
ｂ）媒体に格納
ｃ）オンライン出力
④
エンド
⑤

[Key to previous page:]

A Figure 10
1 Reproduction of color image
2 VFZ image file is input to a computer for reproduction (or a workstation) on-line or via a medium
3 VFZ image file is decompressed in order to reconstruct image data
4 Image data is output
a) Output directly onto the screen
b) Stored into the medium
c) Output on-line
5 End
6 Reproduction conditions are input

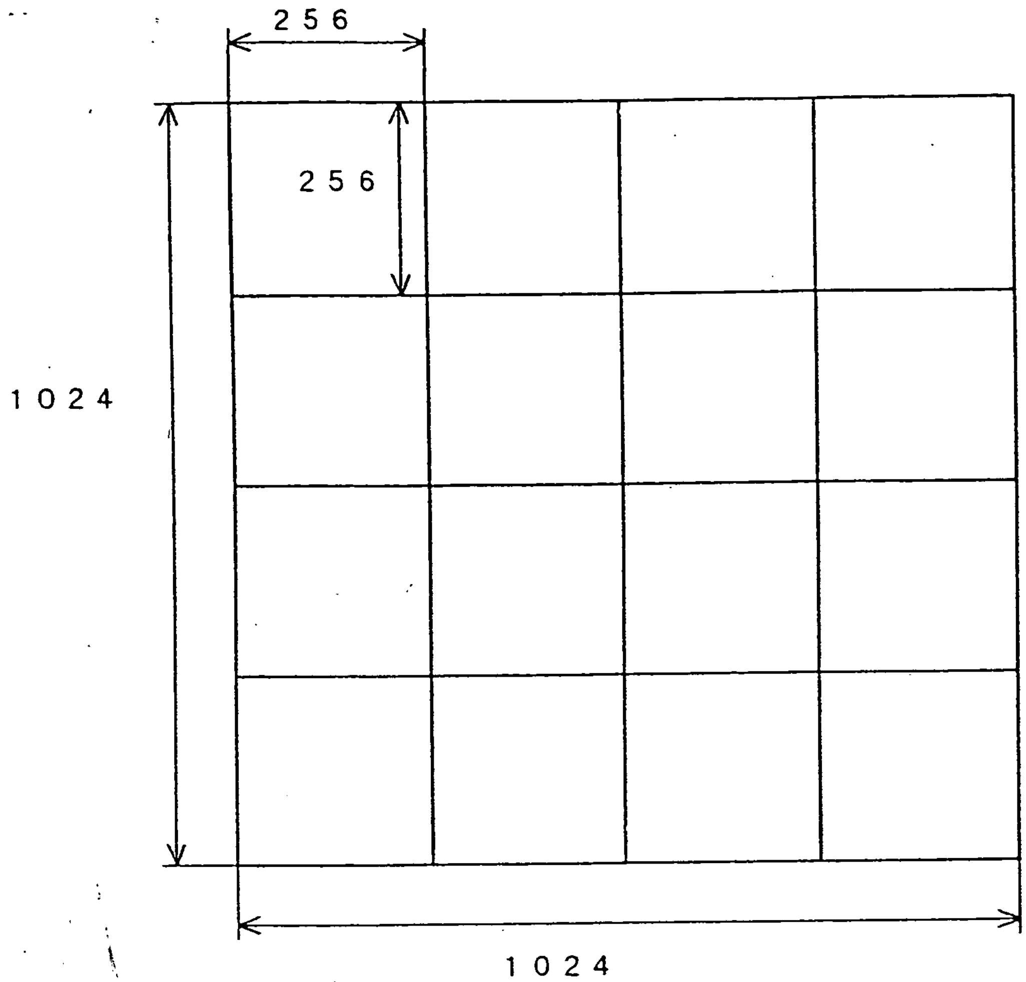
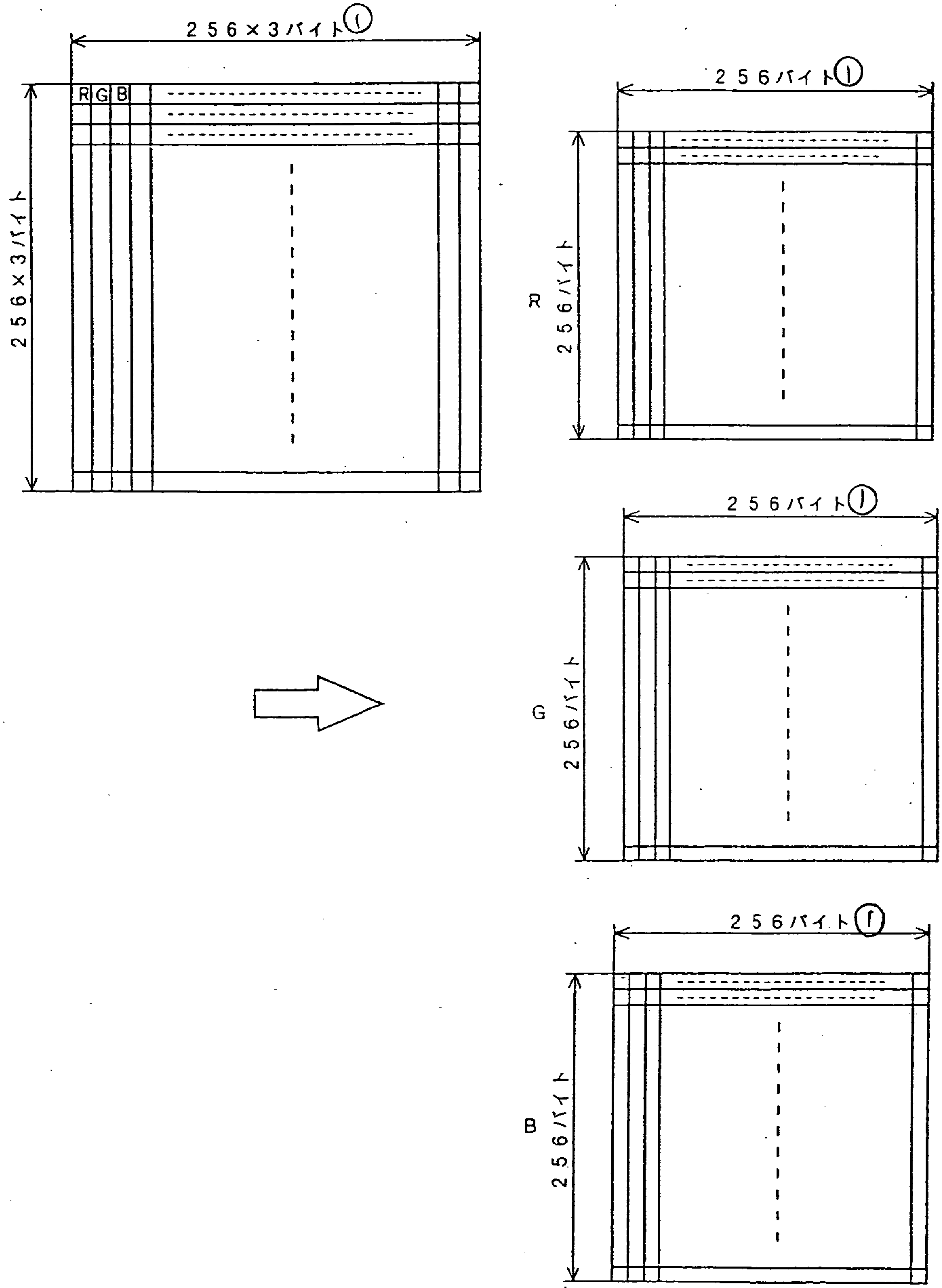


Figure 11

Ⓐ図１２



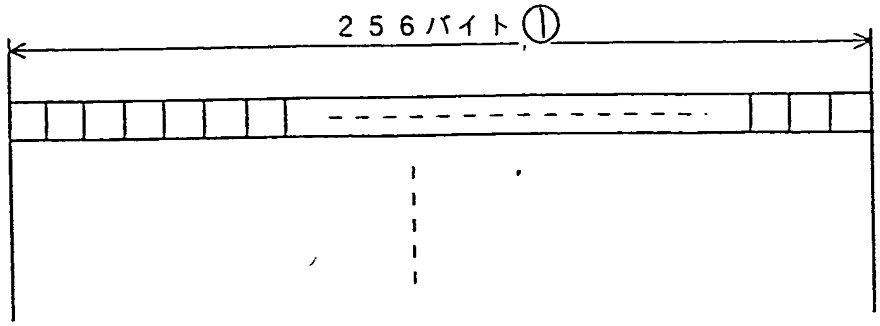
２５６×３バイト①
R
G
B
２５６×３バイト
２５６バイト①
R
２５６バイト
２５６バイト①
G
２５６バイト
２５６バイト①
B
２５６バイト

[Key to previous page:]

A Figure 12
1 Bytes

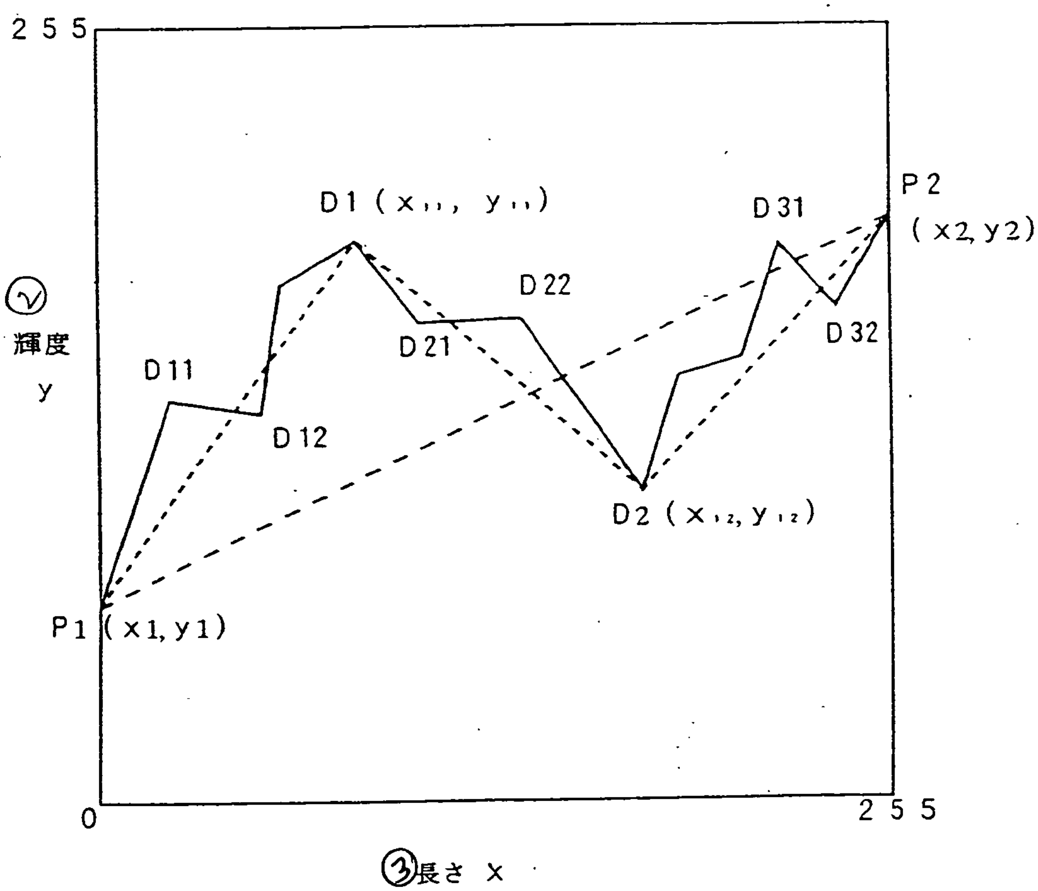
Ⓐ図１３

(A)



２５６バイト①

(B)

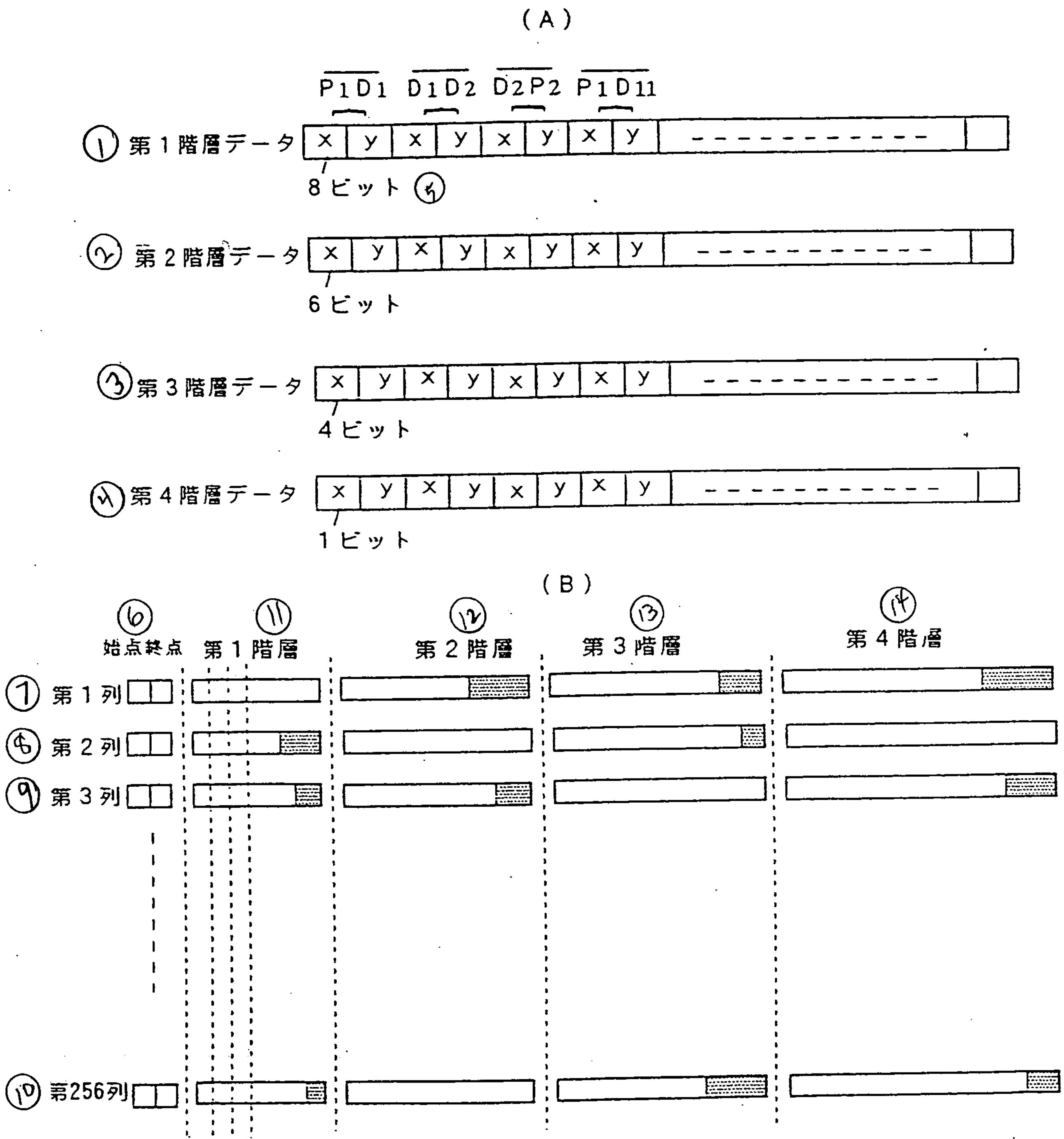


２５５
D1（x_{11}, y_{11}）
D31
P2
（x2, y2）
②
輝度
y
D22
D11
D21
D32
D12
D2（x_{12}, y_{12}）
P1（x1, y1）
0
２５５
③長さ x

[Key to previous page:]

A	Figure 13 (A), (B)
1	Bytes
2	Luminance
3	Length

図１４Ⓐ


(A)
$\overline{P_1 D_1}$ $\overline{D_1 D_2}$ $\overline{D_2 P_2}$ $\overline{P_1 D_{11}}$
1 第１階層データ
x y x y x y x y
8ビット 5
2 第２階層データ
6ビット
3 第３階層データ
4ビット
4 第４階層データ
1ビット
(B)
6 始点終点
11 第１階層
12 第２階層
13 第３階層
14 第４階層
7 第１列
8 第２列
9 第３列
10 第256列

[Key to previous page:]

A	Figure 14 (A), (B)
1	First hierarchical data
2	Second hierarchical data
3	Third hierarchical data
4	Fourth hierarchical data
5	Bytes
6	Starting point/end point
7	First row
8	Second row
9	Third row
10	256th row
11	First hierarchy
12	Second hierarchy
13	Third hierarchy
14	Fourth hierarchy

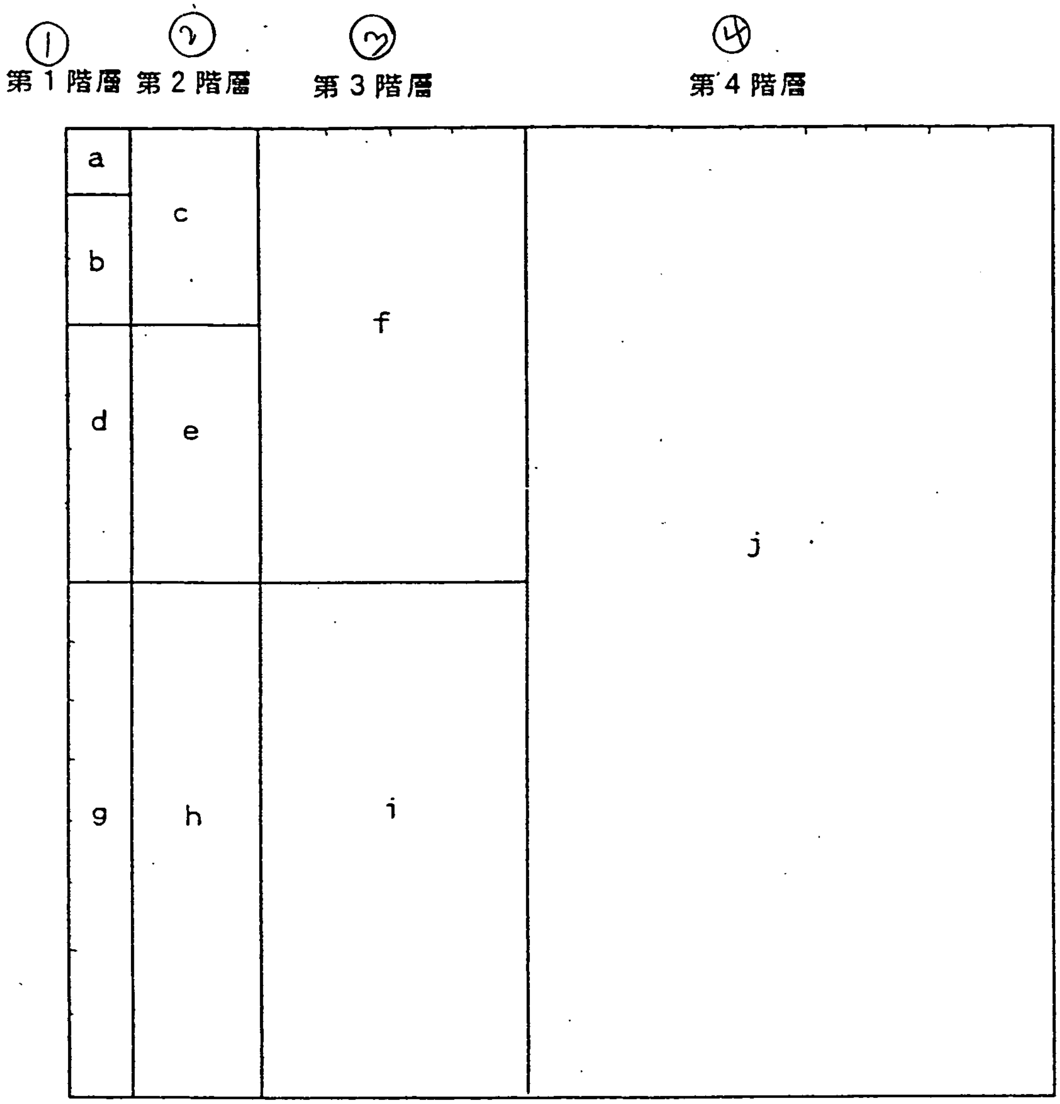


Figure 15

Key:
1 First hierarchy
2 Second hierarchy
3 Third hierarchy
4 Fourth hierarchy

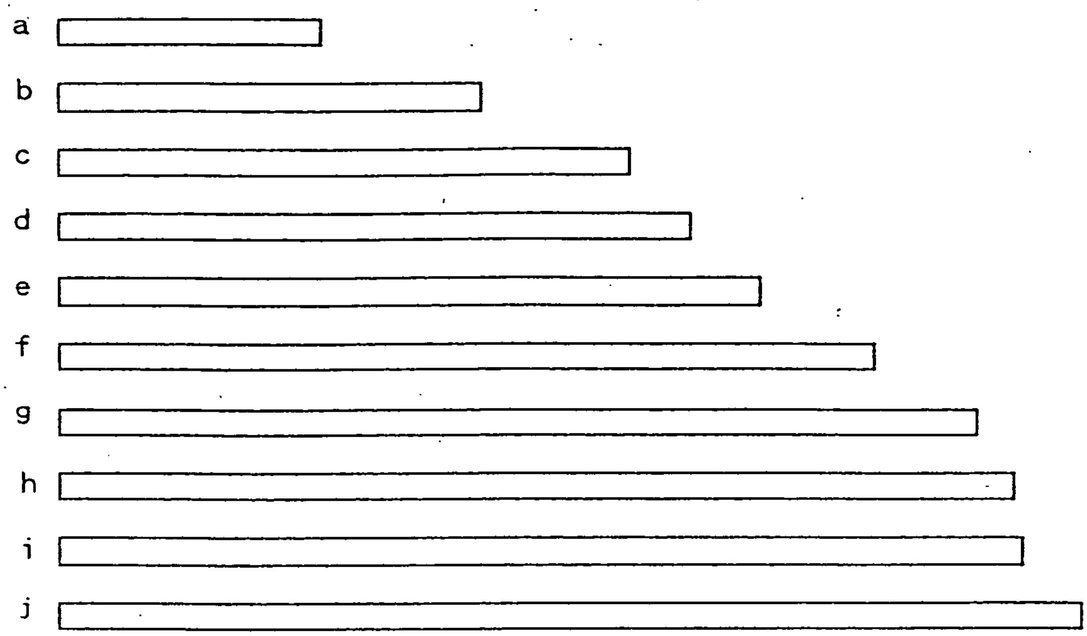


Figure 16